GEOLOGIC ROAD LOG
SPANISH FORK, UTAH TO PRICE, UTAH

by

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INTRODUCTION

The state of Utah has, within its borders, exposures of some of the world's most spectacular geology. In order to assist the public to a greater awareness and appreciation of that geology, road logs and geological descriptions of certain localities are being made available. These road logs are written for use by the general public. There has been an attempt to "keep things simple" by avoiding the use of too much scientific nomenclature. Where unfamiliar terms or concepts are necessary, these have been defined in the text and, in some cases, in the glossary. Glossary and other appendices are included after the road log.

There are some important overall concepts that should be kept in mind as you examine the geology.

<u>**Concept 1**</u> - The Earth is very old, approximately 4.5 billion years old, and rocks have been formed throughout much of that history. In fact, rocks are being formed at the present time.

<u>**Concept 2**</u> - Rocks are the result of matter interacting with energy and natural forces. Because of this, rocks become a record of the energy and forces that were operating at the time and at the place of the rocks' formation. For instance, a volcano erupts in an area and showers molten rock fragments over a wide area. This would result in a rock being formed. If, some millions of years later, this rock is found and examined by a geologist, it could be inferred that this rock represents an ancient volcanic eruption. This interpretation is based upon the composition (mineral content)

and the texture (how it appears physically) of that rock. Another important factor useful in interpreting rocks is the relationship it has with rocks of different qualities that are adjacent to it.

Concept 3 - Some rocks contain evidences of ancient plant and animal life. These evidences, called fossils, allow the trained geologist to interpret the environment in which the animals and plants once lived. Fossils are most common in sedimentary rocks. Sedimentary rocks are those which form in such areas as oceans, lakes, rivers, glacial regions, and deserts. Fossils are valuable evidence for indicating the environment in which the rock formed and also for indicating the geologic age of the rock.

Concept 4 - The Earth is constantly changing its terrain and therefore the environments in which rocks form. This means that rocks, which are the product of these environments, will display this change in a vertical sequence. Rocks also change character in a horizontal direction. If the rocks that show horizontal change are the same age, then the change indicates different, but associated environments, such as land next to an ocean.

Concept 5 - The principal reason for terrain change on the Earth is the movement of large segments of the Earth's exterior, referred to as lithospheric plates or simply plates. These plates can come together, move away from each other, or slide by one another (See glossary).

Concept 6 - Rocks record the ever changing character of the Earth's exterior and near surface exterior.

Concept 7 - All, or nearly all, economic products have their source from the Earth. How society treats this source will largely dictate the future welfare of that society. Ores provide metals; sand, gravel, clay, and rocks are taken from quarries; oil, gas, and coal are earth borne fossil fuels.

In order to get the most from the road log it would be well to read the log for the features that are some distance ahead of you. This allows for some anticipation and preparation for stops.

Also great care should be taken when driving along the highway and making the various suggested stops. Groups, such as student groups, should be closely supervised and schooled in the hazards of stopping, standing, or walking along the highway. Also it can be dangerous to climb upon the rock exposures. There is the possibility of falling or dislodging a rock that could hit others.

Most stops are available to busses. Caution should be exercised at some stops because vehicles can sink into the soft understrata if it is wet.

The road log is designed to be run either from Spanish Fork to Price or from Price to Spanish Fork. For those going from Spanish Fork the road log reads as a normal book. If you are coming from Price you should start at the last page of the road log and read the material from the bottom of the page upward, item by item.

Mileage will be on the left side of the log for those coming from Spanish Fork and on the right side of the log for those coming from Price. The metric equivalent for the miles and feet units are included as a convenience for those people more familiar with the metric system.

The geology that is represented along the route can be divided into two main groups, Basin and Range style geology and Colorado Plateau. Basin and Range style geology is found on the western most part of the route, west of the Wasatch Fault; which is found at the base of the Wasatch Mountains (Fig. 5). Basin and Range style geology is characterized by a series of disconnected mountain ranges that have intervening valleys. The mountains are fault bounded. In contrast, Colorado Plateau style geology is characterized by relatively high areas that often are made up of relatively flat or low dipping rocks. On the average the Colorado Plateau area is of much higher elevation than the Basin and Range.

Nearly all the route is in the Colorado Plateau style geology. With the exception of the older rocks, Paleozoic to Lower Cretaceous, the rocks are flat lying. The younger rocks, part of the Cretaceous and Tertiary, also represent deposition in freshwater lakes and rivers. Faults are present but most of them are small and not as prominent as those found in the Basin and Range province. All the rocks seen on this route are sedimentary; although some igneous, mostly volcanic rocks are found within a few miles of the route.

Many of the sedimentary rocks contain fossils. These fossils permit the trained geologist to interpret the type of area that the sediment accumulated. On one stop there is an opportunity to collect some of these fossils.

ROAD LOG

Spanish Fork to Price, Utah Miles (Km)		Price to Spanish Fork, Utah Miles (Km)
	SPANISH FORK - POP. 9823 (1980 CENSUS) ELEV. 4530 FEET (1381M)	

Spanish Fork has one of the oldest documented histories in Utah. As early as 23 September 1776, two Franciscan friars, Father Francisco Atanasio de Dominguez and Father Sylvestre Velez de Escalante; camped in the area and recorded their observations. Spanish Fork derives its name from these early observations and designations. Spanish Fork formally became a city in 1855. Its economy is based mainly on agriculture and local or valley businesses. It has had periodic influxes of immigrants from Denmark, Iceland, England, Ireland, Scotland, Wales, Norway, and Sweden, particularly in the mid to late decades of the 1800's.

0.0 (0.0) --- **STARTING POINT** - Intersection state highway 214 and 800 N. Spanish Fork (Fig. 1). Provo Level of Lake Bonneville. This level is the broadest level in the valley and is the level upon which most of the housing in the valley is located. The vista to the east show the remarkable flat irons at the base of the mountains these --- 66.0 (106.3) triangular shape spurs are indicators of the Wasatch Fault which is a predominant feature along the front of the mountains (Fig 2). About 100 feet above the base of the mountains is another lake terrace. This is the Bonneville terrace and indicates a level of the ancient Lake Bonneville when it was at its highest and therefore deepest.

The mountain range is called the Wasatch Mountains and marks the division between two important geological provinces; the Colorado Plateau province to the east and the Basin and Range province to the west. If one looks to the west you can see that the mountain ranges are discontinuous; whereas to the east the mountain ranges are continuous and at a much higher elevation.

3.2 (5.2) --- Intersection of 214 and 6. To the south one can see the large cross erected there in memory of the Dominguez and Escalante expedition that came here in late September, 1776. These Spanish explorer missionaries referred to the Utah Valley as "El Valle de Nuestra Señora de la Merced de la Timpanocuitzis" or Our Lady of Mercy Valley, with the Spanish version of the Indian reference to Timpanogos. --- 62.8 (101.1)

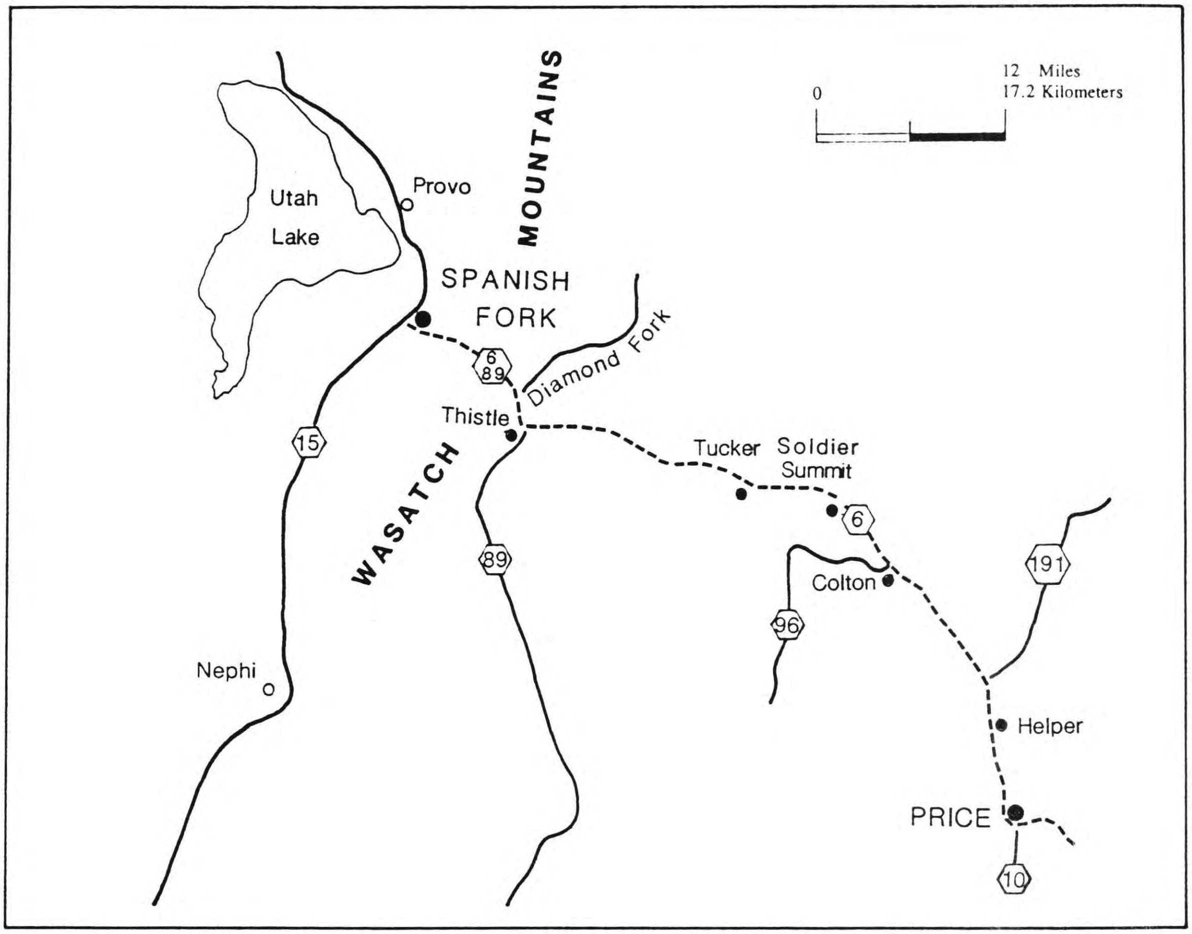


Figure 1 - Index map of field trip route. Route is 66 miles (106.3 km) long and is depicted here as the dashed line. Black dots represent the towns and townsites situated along the route.

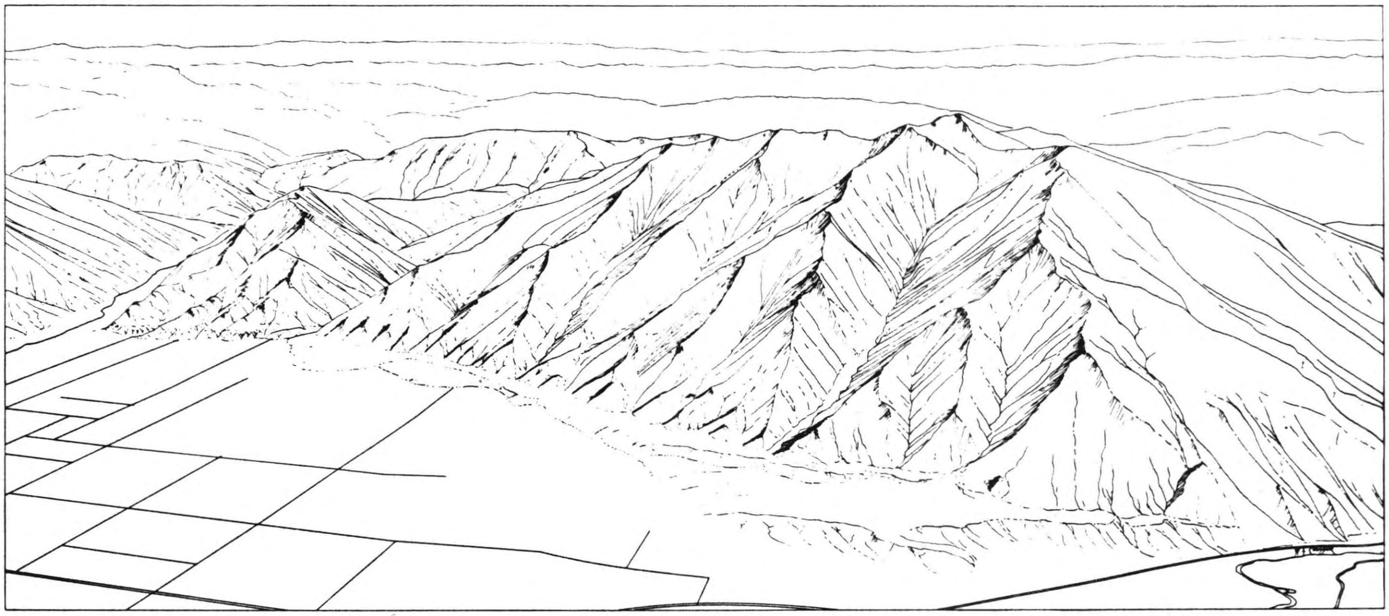


Figure 2 - Sketch of prominent "flatirons" or faceted spurs seen at the base of the mountains as viewed at Stop A. Sketch was made from a low angle air photo by William Chesser and was provided by the courtesy of Dr. W. Kenneth Hamblin.

3.8 (6.1) --- **STOP A** - From this stop one can see the well developed Bonneville level of the ancient Pliestocene lake, Lake Bonneville. Also evident, at this stop is the characteristic topography of the Basin and Range Province to the west and the Colorado Plateau to the east. The triangular facets at the base of the mountain are easy to discern. The Dominguez-Escalante monument cross is on the low hill to the southeast (Fig. 3). --- 62.2 (101.1)

3.9 (6.3) --- Cross the railroad intersection. To the northeast and southwest is the well developed Bonneville level of Lake Bonneville. --- 62.1 (99.9)

4.4 (7.1) --- Cross the Wasatch Fault (Fig. 4, Fig. 5). --- 61.6 (99.1)

4.8 (7.7) --- Outcrop of the Oquirrh Formation. It is the oldest formation seen on this trip. The rock is mostly siltstone (sedimentary rock). Its dark black color comes from organic matter. --- 61.2 (98.5)

5.5 (8.9) --- Upper portions of the Oquirrh Formation can be seen in the outcrops next to the road. These outcrops are much lighter in color indicating that they have less organic material. There are fossils found in this outcrops but they are very small fossils, referred to as fusulinids. Fusulinids are examples of ancient protozoans or one celled animals. Small faults can be seen in outcrops --- 60.5 (96.3)

Figure 3 - Lake Bonneville terrace can be seen just south of the railroad cut. This terrace represents the highest level achieved by the ancient lake. The elevation at the top of the terrace is 5100 feet (1555 m). The cross in the middle of the photo commemorates the Dominguez-Escalante expedition.

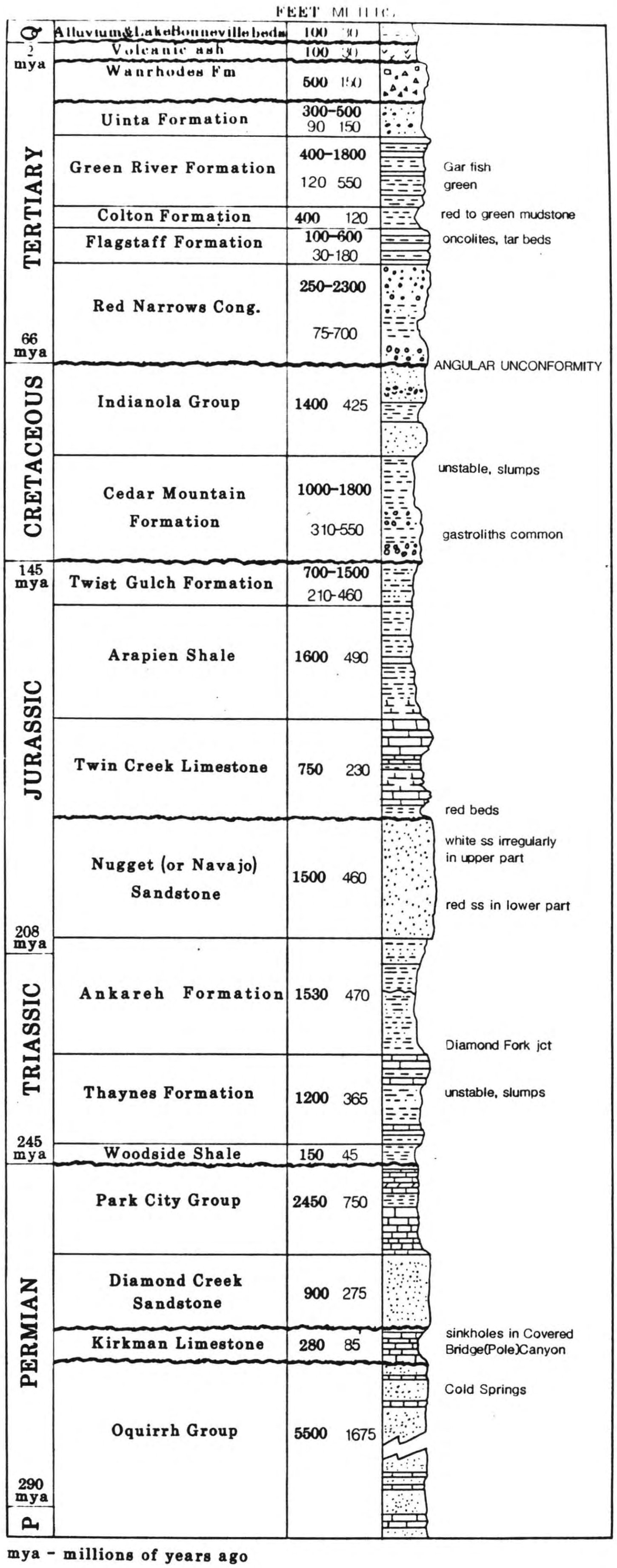
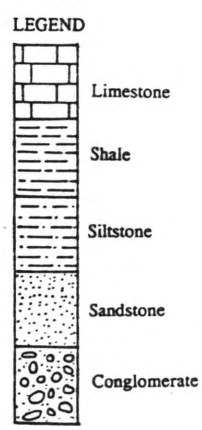


Figure 4 - Rock column representing rocks seen along the western portion of the route, from Spanish Fork to Soldier Summit. See cross-section (Figure 5) for the spatial relationship of these rocks.



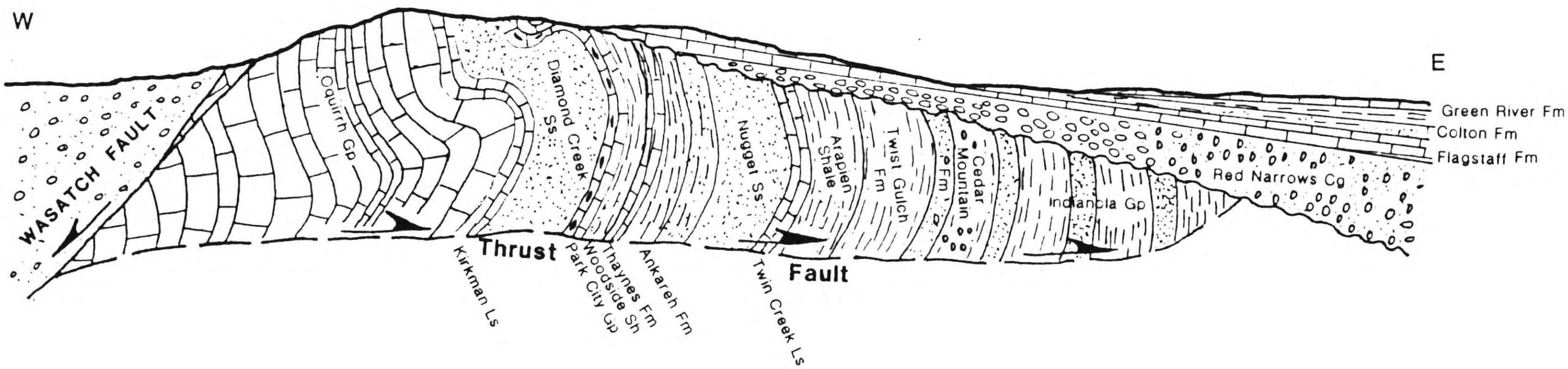


Figure 5 - Geologic cross-section of rocks as interpreted from available geologic data. This diagram is modified from Rigby (1968).

if one looks carefully in this area.

6.8 (10.9) --- Outcrops of the upper portions of the Oquirrh Formation can be seen to the east. Note how the bedding is at a high angle and also the rocks are highly fractured. Rocks that are fractured like these, indicate that the earth has moved when the rocks were in a brittle state causing them to break up. --- 59.2 (94.3)

7.3 (11.8) --- Remnants of ancient river terraces can be seen to the east. These are evidence of a change in deposition and erosional patterns. --- 58.7 (93.4)

7.6 (12.2) --- The valley opens up. Kirkman Limestone is found in the low hills. The Kirkman Limestone is a soluble limestone and allows for development of sinkholes(Fig. 6, Fig. 7). --- 58.4 (93.0)

An alluvial fan can be seen to the east. Outcrops of the Diamond Creek Sandstone. This sandstone is the same age equivalent rock that has oil deposits in it in Colorado.

8.6 (13.8) --- Outcrops of high angle Diamond Creek Sandstone. Note how badly broken the sandstone is. This, too, is the result of earth movements. --- 57.4 (91.4)

9.4 (15.1) --- Outcrops of the Park City formation can be seen to the east. --- 56.6 (90.4)

9.5 (15.3) --- Red outcrops the Triassic age, Woodside Shale and Thaynes Formation badly slumped soils --- 56.5 (90.2)

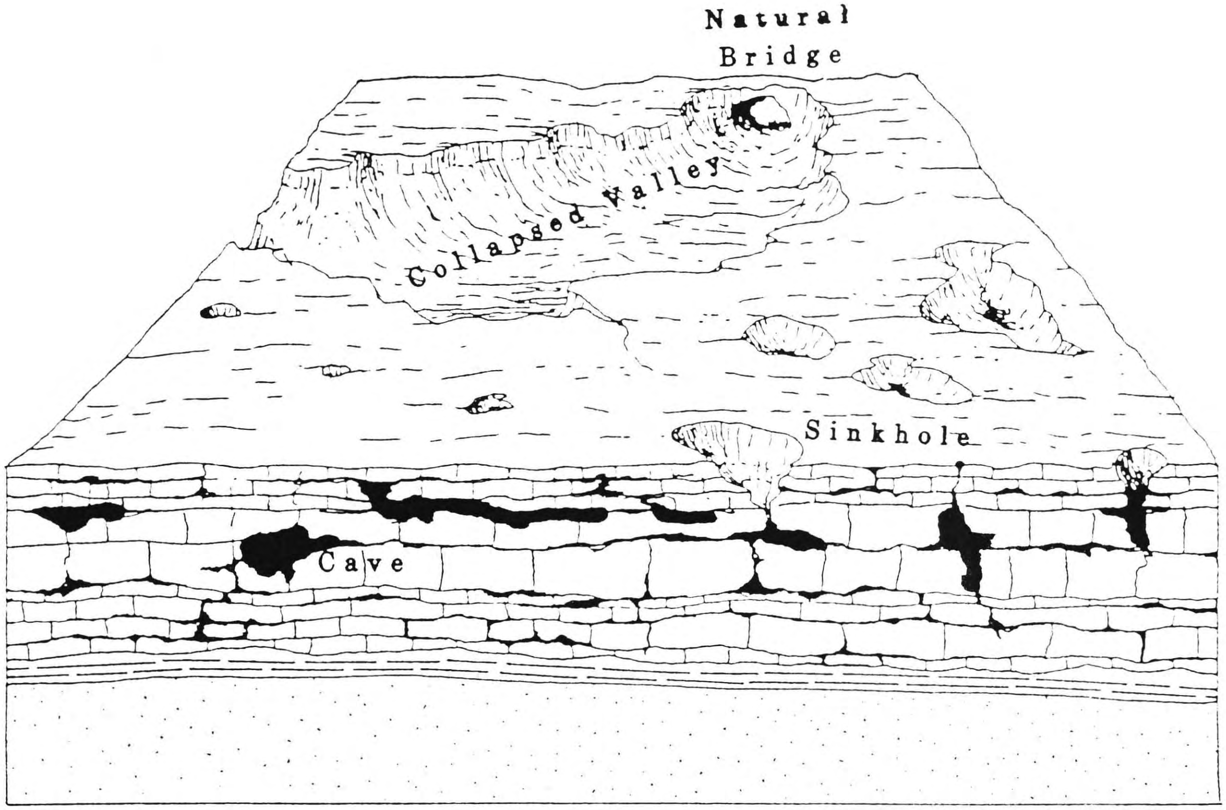


Figure 6 - Diagram depicting sinkhole and karst conditions as found near Covered Bridge (Pole Canyon) mile 7.6 (12.2 km). The Kirkman Limestone is the host rock for these sinkholes. Caves develop first then sinkholes result from collapse of the roof. Collapse valleys develop from connecting a series of sinkholes. Natural bridges are not common. Only sinkholes and collapse features are present at this site (modified from Rigby, 1968).

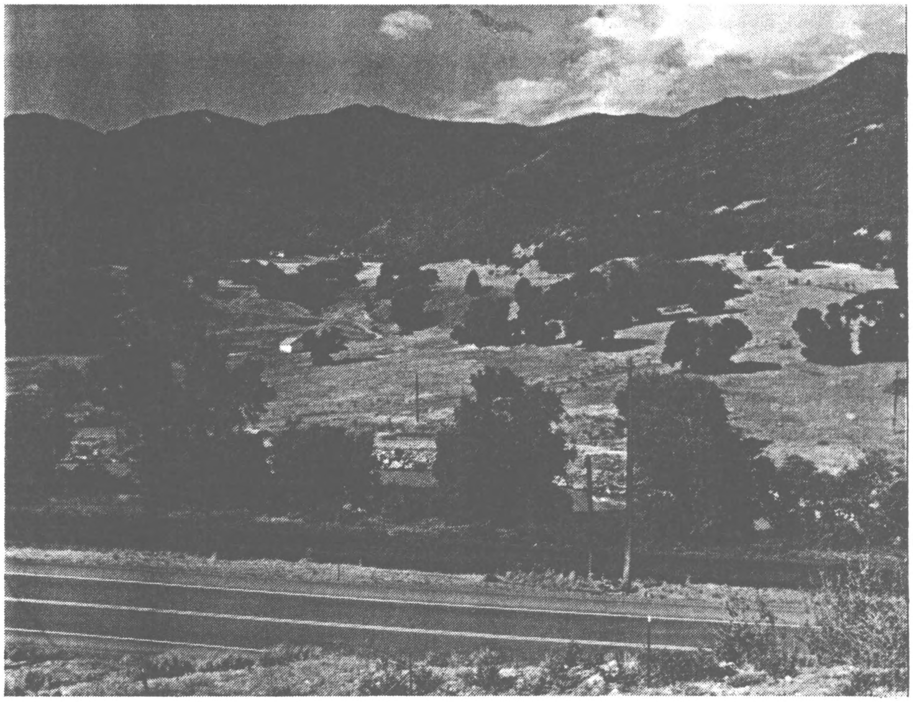


Figure 7 - Karst or solution topography at the mouth of Pole Canyon. Groundwater seeping through the Kirkman Limestone dissolved the rock in places thereby creating large caverns. Some of these caverns collapsed leaving sinkholes on the surface. A large collapse structure can be seen just to right of the white building.

and rocks. These rocks fail because they are fine grained shales and siltstones that lose strength when they have water added to them or the slope is cut into by during construction of the new highway or erosion.

10.1 (16.2) --- Entrance to the Palmyra Campgrounds - Diamond Creek. --- 55.9 (89.3)

10.4 (16.7) --- Exposures of the Ankareh Formation. This area shows many slump features. These rocks are mostly sandstones and siltstones and are representative of an ancient tidal flat environment. --- 55.6 (89.0)

10.8 (17.4) --- Small fault can be seen on the east side. Ancient bars and channels on the west. --- 55.2 (88.3)

11.1 (17.9) --- The massive sandstone cliffs to the front are referred to as the Navajo or Nugget Sandstones. These sandstones represent an ancient desert that stretched from Montana to areas south of Arizona. --- 54.9 (87.8)

12.1 (19.5) --- **STOP B** - The Thistle Landslide. One of the most dramatic geologic hazards to occur in Utah was the Thistle landslide of mid April, 1983 (Fig. 8). --- 53.9 (86.2)

What began as a noticeable misalignment of the railroad tracks discovered on the morning of Wednesday, April 20, 1983, continued with these same tracks being ripped apart,

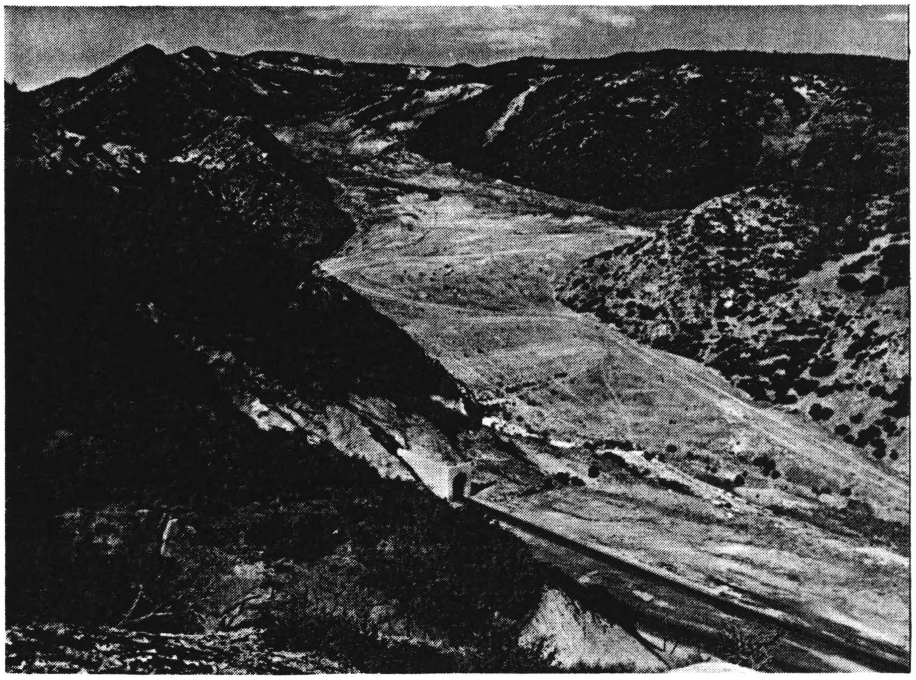


Figure 8 - The Thistle Slide can be seen here in its entirety. The slide material oozed down the valley in mid April, 1983. Highway and railroad transportation were brought to a halt and the town of Thistle was inundated by the impounded waters. The highways and railroad were relocated and Thistle was abandoned.

transported and covered over with by 230 feet (70m) of water saturated clays, siltstones, and other rocks. In 8 days this mass of rock and debris had been slowly transported down slope. As the mass impinged against the bedrock on the north east side of the canyon the result was a gradual increase in height and width of the slumping mass. With the increase in height the Spanish Fork River was slowly being dammed. Despite using heavy equipment to keep the channel open, the effort was abandoned on Sunday April 17, as it became apparent that it was useless to continue.

With the closing of the canyon by the slide, the impounded waters rose quickly creating a lake, dubbed "Lake Thistle". This lake would eventually be about 200 feet (60 meters) deep and inundated the town of Thistle. Houses and other buildings floated from their foundations and became part of the floating debris in the lake.

As the lake waters increased and the landslide stabilized the problem was to keep the water from topping the dam created by this moving mass. Should the water top the dam then there could be an enormous flood downstream as the waters eroded the landslide. Pumps were installed on a barge and these operated for a few months to keep the water level below the top of the landslide.

The Thistle Landslide caused millions of dollars in damage but no loss in life. The railroad and highways had to be rerouted at an additional cost of tens of millions of dollars and the town of Thistle was essentially wiped out.

Could this geological hazard been prevented? Probably not. The configuration of the canyon is such that there was no other practical spot to put the railroad and highway. The mass of rock, mostly from the North Horn Formation, that made up the landslide was saturated by percolating waters the product of three unusually wet years. It was inevitable that the mass would one day move if it became sufficiently saturated. The area, where the slide occurred, had a long history of land failure. This area of the railroad tracks was constantly being monitored for any sign of movement and occasionally the earth had moved enough to cause the tracks to be repaired. Even though the area had a history of ground failure that was known to geologists and engineers, the scale of the landslide was a surprise. Approximately 30 million tons of material had been transported downslope over a period of 8 days.

The landslide now lies relatively dormant. The water from the upper part of the Spanish Fork now comes through a tunnel.

12.3 (19.8) --- Excellent exposures of the Jurassic Twin Creek Limestone (Fig. 9) --- 53.7 (85.9)

12.5 (20.1) --- **STOP C** - Angular unconformity- Figure 10. --- 53.5 (85.6)

13.2 (21.3) --- These many slump features and landslide are exposed here, associated with upper Jurassic formations. These land failure features were initiated after the road cuts were made during the construction of the new highway. --- 52.8 (84.8)

13.5 (21.7) --- Intersection between highways 6 and 89. Road to south goes through the townsite of Thistle. THISTLE - Unincorporated, 4980 feet 1518m. Thistle got its name from "Camp Thistle" an early railroad that was operating at the site in the early 1870's. Most of the history of Thistle revolves around being a railroad crossroads. It was a community of more than six hundred people by 1917. Thistle survived a series of small floods, droughts, and economic depression until it met a problem too big to handle, namely the Thistle Landslide --- 52.5 (84.4)

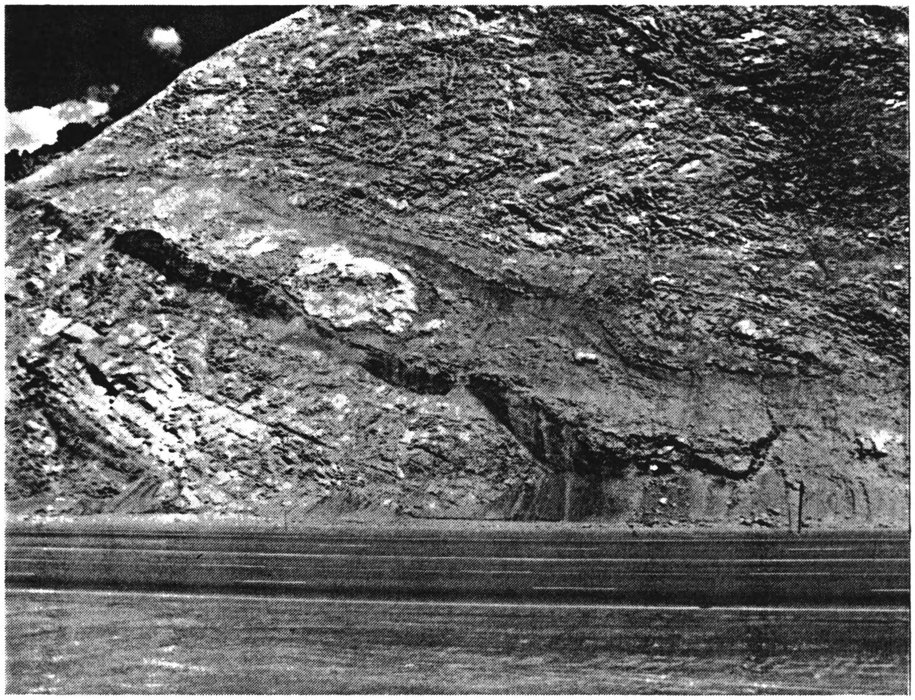


Figure 9 - Sedimentary limestones, gypsum, and siltstones of the Twin Creek Limestone. These rocks are approximately 170-180 million years old. These rocks are thought to represent an ancient shallow sea depositional sequence.

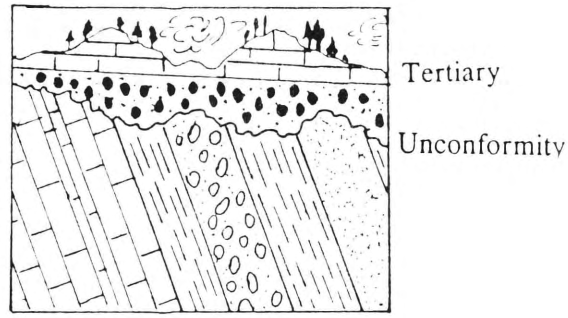
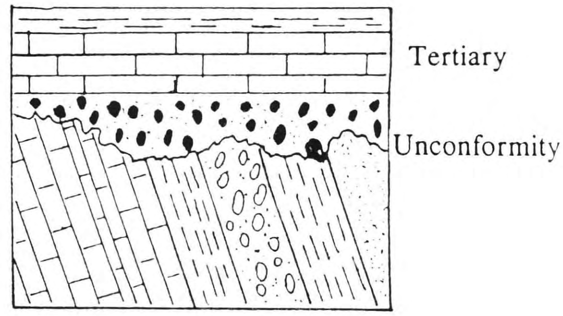
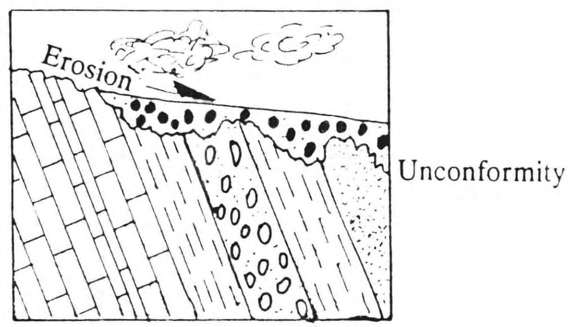
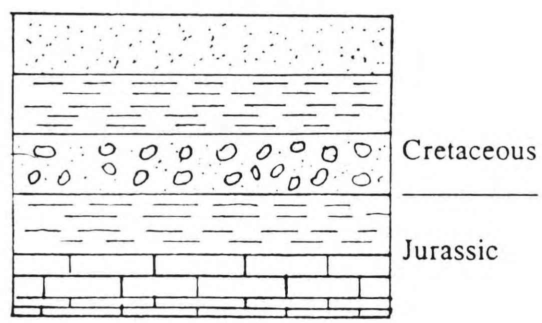
GEOLOGIC PROCESSES	DURATION	RESULT
Sedimentation in freshwater lakes and rivers continues- more volcanic activity locally and in Western Utah. Land is gradually being uplifted until a new erosional surface is being made. Perhaps sometime it will be an unconformity.	Approx. 35,000,000 years	 35 mya to present
Sedimentation continues in mostly freshwater lakes with some river deltas present. Land gradually subsides and sediments become rock.	Approx. 35,000,000 years	 70 to 35 mya
Mountain building continues, rocks are folded and thrusted eastward. Erosional processes wear down the exposed rocks. These eroded sediments will make up the Red Narrows Conglomerate and younger Tertiary formations.	Approx. 50,000,000 years	 120 to 70 mya
Sedimentation in shallow seas. Mountain building is in progress in western Utah.	Approx. 60,000,000 years	 180 to 120 mya

Figure 10 - Diagrammatic interpretation of the development of the angular unconformity, seen at Stop C.

of late April, 1983.

13.7 (22.1) --- Outcrops of the Cedar Mountain Formation. The rock is mainly made of marine materials, with some channels made of continental materials. --- 52.2 (84.0)

14.4 (23.2) --- **STOP D** - Major slope failures (Fig. 11). North side of the road, high on the hillside are outcrops of the Flagstaff Formation. --- 51.5 (82.9)

14.9 (24.0) --- These rocks are gently dipping to the west and the north whereas the rocks below are at a high angle. --- 51.0 (82.1)

15.3 (24.6) --- Rocks here are essentially horizontal and we are in the rocks that are in the upper Cretaceous age and lower Tertiary age. These conglomerates were formed at the edge of an ancient mountain range. Rivers that deposited these rocks flowed to the east whereas the present drainage flows to the west. Many of the conglomerate and sandstone beds are highly fractured. They are fractured in more than one direction and this allows the rocks to be weathered in such a way that they leave pinnacles and spires, as the weathering precedes more rapidly along the fractures. These kinds of spires and things are referred to as hoodoos and can be seen very nicely at mile 16.8 (22.9) (49.8 miles (80.2 km) from --- 50.6 (81.4)

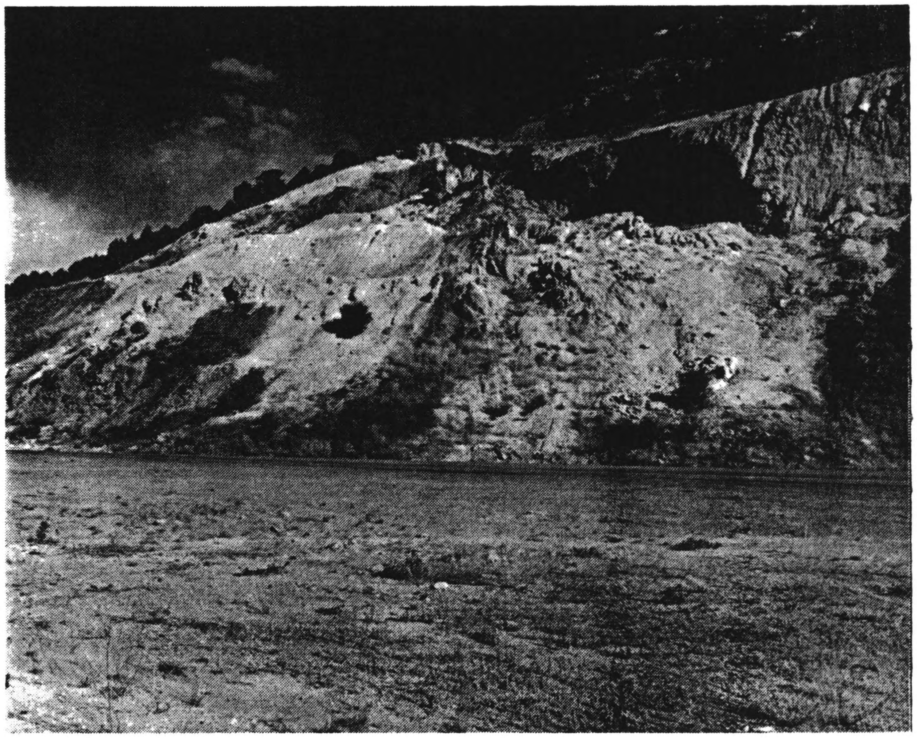


Figure 11 - One of the many slope failures found along the roadside. These slope failures are the result of cutting away of weak Jurassic and Tertiary rocks for the new highway alignment.

Price start) on the northwest side of the road.

17.0 (27.4) --- Outcrops of the Red Narrows Conglomerates. The conglomerates again are indicators of rivers and streams that moved large particles off the front of the ancient mountain. Note the various size of boulders and cobbles that make up this formation. --- 48.9 (78.6)

17.7 (28.5) --- Outcrops of the Red Narrows Conglomerate (Figs. 12, 13). These rocks are relatively flat here but one can see the channels that make up this rock very easily here. Rocks of the Red Narrows Conglomerate are becoming gradually finer grained and the sandstones and conglomerates give away to sandstones and siltstones and some cases limestone. --- 48.2 (77.5)

18.8 (30.3) --- **STOP E** - Tufa cone situated along a fault (Fig. 14). Mineral laden groundwater comes to the surface here and the resulting deposit is a limestone that has a very porous structure. --- 47.1 (75.7)

19.1 (30.8) --- Cross a fault. --- 46.8 (75.2)

19.3 (31.1) --- **STOP F** - Outcrops of gray limestone (Figs. 15,16). One can collect algal balls or fossilized algae. These algal balls are the result of calcium carbonate secreting algae that encrusted or surrounded foreign objects, like chunks of mud or shells of gastropods. As time progressed the algae would continue to --- 46.6 (74.9)

Figure 12 - Boulders and cobbles of mostly sandstone and limestone make up the Red Narrows Conglomerate. This formation was formed over 65 million years ago. Rivers brought the cobbles and boulders from the nearby mountains to the west into the eastern lowlands. This formation is considered to be evidence of ancient mountain uplift and consequent erosion by streams. See figures 5 and 10 for geologic position and significance of these rocks.

Figure 13 - Outcrop view of Red Narrows Conglomerate. These rocks were once alluvial fans that formed at the base of ancient mountains.

Figure 14 - This cone shaped hill is referred to as a tufa cone. Mineral laden groundwater, from higher elevations, comes out along a fault. The minerals are gradually deposited as the water seeps out. The deposit, mostly calcium carbonate, can encase leaves, snails, and sometimes small animals thus preserving them as a type of fossil.

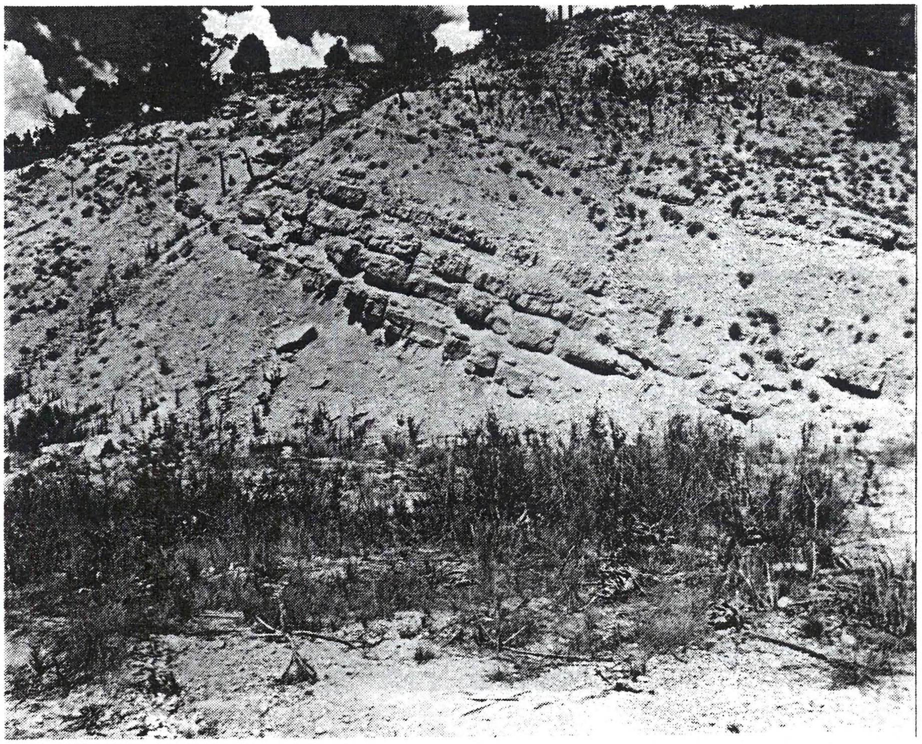


Figure 15 - Limestones of the Flagstaff Limestone are indicative of a freshwater lake that occupied much of central and north central Utah over 60 million years ago.

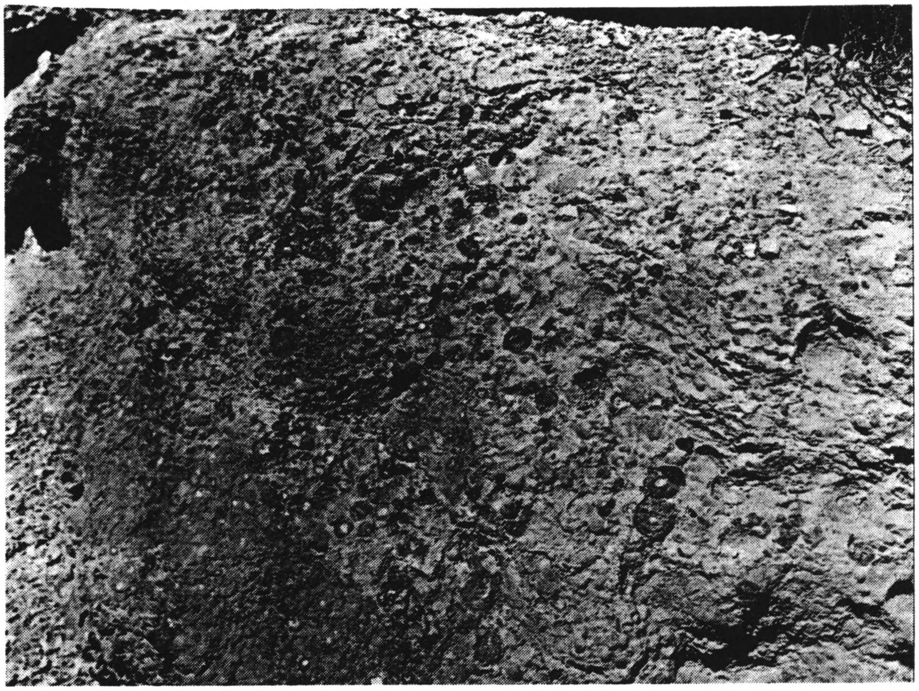


Figure 16 - Close up of Flagstaff Limestone beds that contain numerous algal balls or oncolites. Algae would attach themselves to small objects, such as a snail shell and as they rolled around in the water they would secrete layers of calcium carbonate on the object.

encrust the object layer upon layer until the algae died and was subsequently buried. These became the fossils we find today. These outcrops are the Flagstaff Formation. These rocks are an indication of an ancient lake that occupied this area some 60 to 65 million years ago. Remains of crocodile, turtles and other sub-tropical fossils and fauna have been found in these rocks.

19.9 (32.0) --- The hills here that are relatively smooth in appearance are made up of the Tertiary Green River Formation. This is a world classic example of rocks that formed in ancient lakes. The sandstones, siltstones, shales and other rocks found in this formation are important indicators of this lake. Fossil evidence particularly plant fossils show that the lake was at one time very close to the elevation of the sea and now is found several 1000's of feet higher. Another important aspect of the Green River Formation is that some of the rocks that are found in it contain kerogen and sometimes referred to as "oil shale." The amount of kerogen in this formation is enormous. If oil could be produced economically from the kerogen there would be several billion barrels of oil to be extracted. --- 46.0 (74.0)

20.8 (33.5) --- Sheep Creek Road. --- 45.1 (72.5)

21.4 (34.5) --- Vista of a portion of the Colorado plateau. Rocks are relatively horizontal to gently dipping. Portions of the upper Green River Formation can be seen here also. These rocks are mainly formed in quiet lake deposits. Fossil hippopotamus and camels have been found in these rocks. --- 44.5 (71.5)

22.3 (35.9) --- **STOP G** - Excellent exposure of a fault (Fig. 17). Great care should be taken at this stop to watch out for vehicles.One can examine this fault carefully and gain some indication of the kind of geometry found along big normal faults like the Wasatch Fault. --- 43.6 (70.1)

22.6 (36.4) --- The sandstone body on the north is a channel formed in the ancient lake sediments. These channel deposits were once channels of rivers that moved out into the lake on a delta front. --- 43.3 (69.6)

23.3 (37.5) --- Some of these rocks that are "oil shales" or kerogen-bearing rocks. This is the kind of rock that was being mined and processed experimentally with the objective of extracting oil from them. The process was not very successful and when prices for regular oil dropped the project was abandoned. --- 42.6 (69.5)

The railroad that we follow along here is

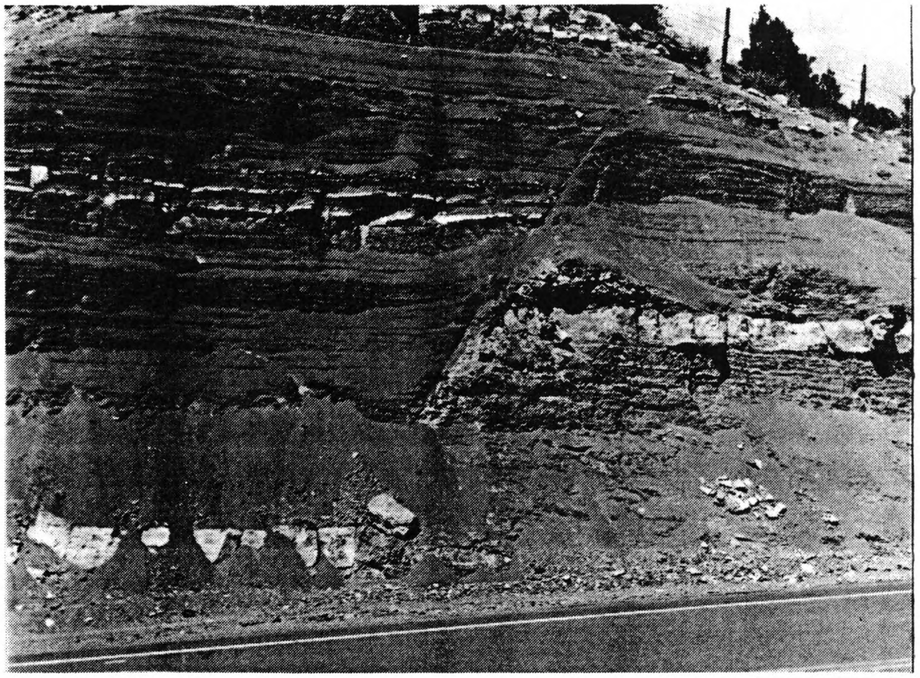


Figure 17 - Small, but prominent, fault in the Green River Formation. Fault plane is easily seen and rock units once continuous can be matched, although displaced, across the fault. This small fault is similar in geometry as the much larger Wasatch Fault found along the eastern side of Utah Valley.

the Rio Grande Western railroad. This railroad and its predecessor played an important part of the early history of the area. All the little towns and former towns found in this area have their history associated with this railroad.

25.1 (40.4) --- Additional rocks contain "oil shale" here. --- 40.8 (66.6)
The upper portions of the Green River Formation contains many fossils including bird tracks and occasionally whole fish.

25.6 (41.2) --- Excellent outcrops of the Green River --- 40.3 (65.8)
Formation. Note how thinly-bedded rock units repeat in a sequence. These cyclic rocks indicate repeated conditions in a regular or rhythmic manner. The inference is that environmental change is also cyclic.

26.6 (42.8) --- Outcrops of the middle portions of the --- 39.3 (64.2)
Green River Formation. Formation gets up to 2,000 feet thick.

26.7 (43.0) --- Cross over the railroad. --- 39.2 (64.0)

27.5 (44.3) --- Outcrops of the middle portion of the --- 38.4 (62.7)
Green River Formation can be seen along the cutaways of the railroad. If one looks carefully one can see a series of small faults in some of the railroad cuts.

28.0 (45.1) --- Roadside Cafe. --- 37.9 (61.9)

28.2 (45.4) --- Extraordinary outcrops of rocks --- 37.7 (61.6)
representing the deeper water portions of the

lake can be seen in the railroad cuts to the east and north.

28.6 (46.0) --- Outcrops of large channel deposits --- 37.3 (61.0)

28.7 (46.3) --- **STOP H** - Series of faults can be seen in the outcrop directly to the northeast (Fig. 18). --- 37.4 (60.7)

29.2 (47.0) --- Outcrops of the middle portions of the Green River Formation. Channels deposits can be seen. The number of channels is increasing in this area. --- 36.9 (60.0)

29.6 (47.7) --- Rest Area. This area is also the former site of the town Tucker. Tucker had its heyday from 1870 - 1880 when it was a railroad camp on the narrow gauge railroad system called the Pleasant Valley Railroad. This system was later expanded and renamed the Denver and Rio Grande Railroad. During its high activity times Tucker was the main cattle and sheep shipping center. After 1880 its activity level dropped considerably, and Tucker had a very small population. With the advent of diesel engines in the late 1940's the town's reason for existence was removed. Nearby rock outcrops can be examined for fossils (Fig. 19). Particular fossils can be found including bird tracks as well as plant remains and plates of fish and occasional scoots from turtles and --- 36.4 (59.3)

Figure 18 - Small fault blocks in the Green River Formation. Many of these small faults are caused by the rock adjusting to being uplifted. There is evidence that indicates that the rocks have been elevated over 12,000 feet (3660 m) in the past 25 to 30 million years.

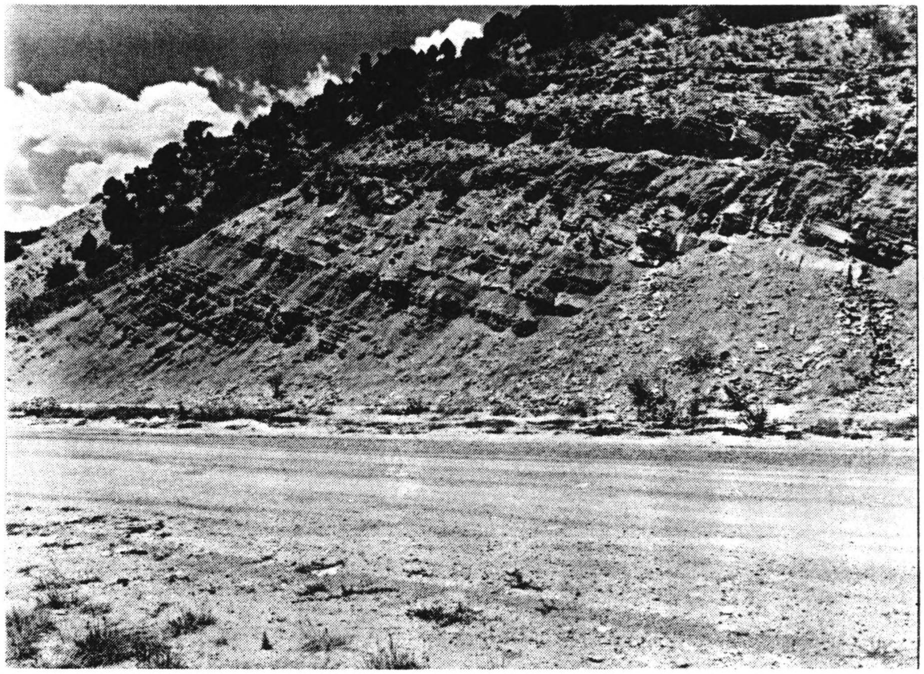


Figure 19 - Outcrops of the Green River Formation have beds that are organic-rich. Some of these beds have sufficient amounts of organic matter (kerogen) to be considered as an "oil-shale". Such rocks, where they are thicker and contain more kerogen, were objects of intense study and thermal processing in hopes of extracting liquid petroleum from them at a profit.

fragments of alligators. All are, however, not common.

30.0 (48.3) --- **STOP I** - Fossil Collecting (Fig. 20). --- 36.0 (58.7)
This is an excellent example of an abundance of fossils. Many clams (pelecypods) and snails (gastropods), along with fossil bones from fish, turtles, and alligators can be found here.

30.8 (49.6) --- Valley widens as the rocks are dipping --- 35.2 (57.4)
gently off to the north and northeast. The resistant layers make up the slope in both the near and distant horizon. In several places there are minor mud and soil slides.

31.8 (51.2) --- Cross the railroad. Rocks are of the --- 34.2 (55.8)
Green River Formation.

32.6 52.5) --- The dark brownish-red outcrops are of the --- 33.4 (54.5)
Colton Formation. These rocks are distinctly different from the overlying Green River Formation. It is thought that the difference is caused by sediments that makeup the Colton were derived from rocks that are more red. In sedimentary rocks it is important to realize that particles that make up those rocks come from previously existing rocks and sometimes one can see evidence, in these newly formed rocks, what ancient rocks were like.

33.8 (54.4) --- Excellent outcrops of the Colton --- 32.2 (49.0)

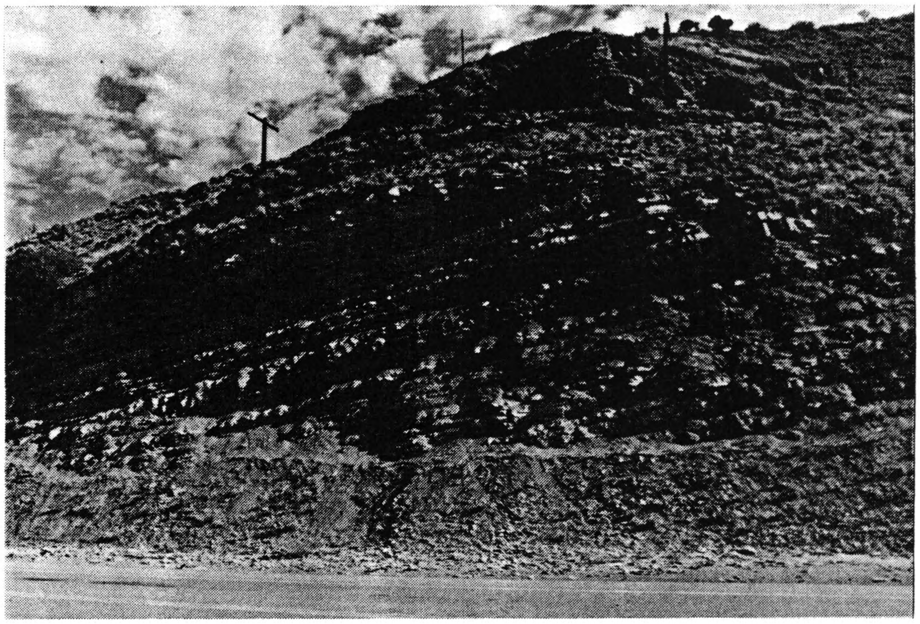


Figure 20 - Much of the Green River Formation has rocks that repeat in pattern that indicate a waxing and waning of the ancient lake waters. Many of the rocks contain abundant fossils, such as the clams rich beds found here. The fossils such as hippos, alligators, fish, palms and turtles indicate that the rocks formed in a subtropical, shallow freshwater lake, much like the modern the Okefenokee Swamp of southern Georgia or the Everglades of Florida.

Formation. These, too, are lake deposits but have a large influence associated with delta deposits, therefore both river conditions and lake conditions are evidenced in these rocks. Many of these sandstone layers contained vertebrate parts and pieces. Among them is evidence of small hippopotamus and small camels. Some of which were not much larger than a large dog.

34.7 (55.9) --- Evidences of large landslides on the southwest side. On the northeast side one can see the outcrops of channels of former rivers that were at one time part of the development of the Colton Formation. Near the summit the soils are thicker because the rocks are horizontal and the weathering processes are more efficient. Some of these thick soils are unstable and will move slightly, occasionally causing trouble spots along the railroad. --- 31.3 (47.5)

34.9 (56.2) --- **STOP J** - At this stop the ancient stream channels can be seen preserved in rock (Fig. 21). These rocks are evidence of an ancient delta complex. --- 31.1 (50.8)

36.4 (58.6) --- Town site of Soldier Summit. --- 29.6 (44.8)

SOLDIER SUMMIT - unincorporated, Elev. 7440 feet, 2268m. Soldier Summit is the highest part of the traverse between Spanish Fork and

Figure 21 - Channel deposit in the Colton Formation. These channel deposits are interpreted as being the remains of streams that once cut into the ancient deltas that formed along the northern edge of a low highland to the south of this outcrop.

Price. It derives its name from the fact that several federal soldiers were buried there in the early 1860's. It is uncertain just who these soldiers were but the concensus is they were soldiers headed east to join in with other units to fight in the Civil War.

Today Soldier Summit is unincorporated but in the decade from 1920 to 1930 it had up to a few hundred inhabitants. Most of the economy was based on the railroad but it had stores, school, train yards, and a hotel.

For those traveling eastward, Spanish Fork to Price, the geology takes on a quite different style. The rocks are much flatter and the Cretaceous rocks of marine origin. Figures 22 and 23 give an indication of this change in style. Those traveling westward are referred to figures 4 and 5. These will show the general geology that you will see.

36.5 (58.8) --- Boundary between Utah and Wasatch Counties. If you look south, you can see evidences where there were several houses. At one time Soldier Summit was a prominent station for the railroad. As we reach the summit the vista becomes very wide. Here at the top of the mountain we reach the water divide. The water from here will drain to the east and --- 29.5 (44.6)

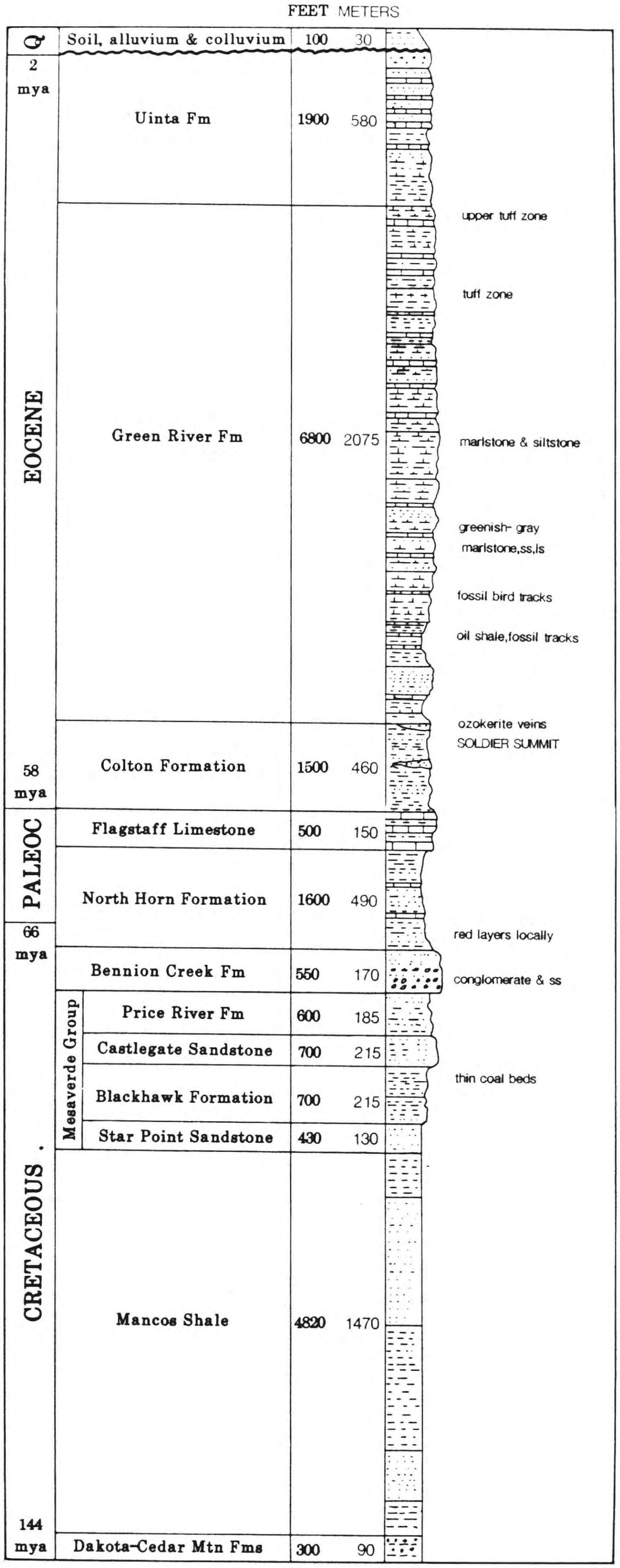
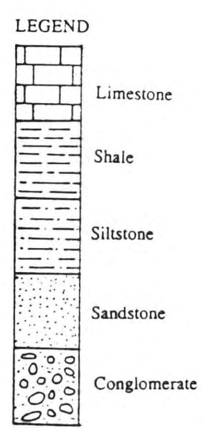


Figure 22 - Rock column representing rocks seen along the eastern portion of the route, from Soldier Summit to Price, Utah. See cross-section (Figure 23) for the spatial relationship of these rocks.



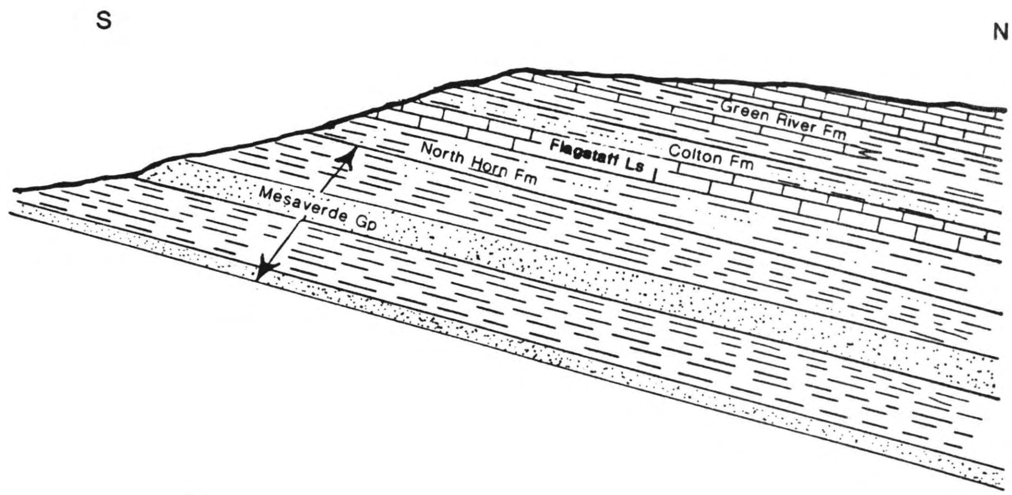


Figure 23 - Geologic cross-section of rocks as interpreted from available geologic data.

become part of the Colorado River drainage. The water on the west side of the divide will work its way to Utah Lake and some of it as far as the Great Salt Lake.

37.7 (60.7) --- Abandoned ozocerite mine. Ozocerite was --- 28.3 (42.7)
mined here in the late 1800's and early 1900's. Ozocerite is a solid hydrocarbon found in veins. It is speculated these solid hydrocarbons or tar-like deposits are the result of oil residue losing its volatiles, leaving behind the solids. The oil or tar was injected into overlying rocks through faults and fractures. Some of the deposits are two to four feet wide veins that extend to great depth. Ozocerite was used in munitions and in making recording record blanks.

38.5 (62.0) --- Road follows the confluence of the White --- 27.5 (41.4)
River. The White River flows east and south to become part of the Price River and thus becomes part of the Colorado River drainage.

39.1 (63.0) --- Wasatch - Utah County boundary. --- 26.9 (40.4)

39.3 (63.3) --- Terraces of the White River can be seen --- 26.7 (40.1)
very clearly off to the east of the road.

40.6 (65.4) --- The canyon is now behind us and we see the --- 25.4 (39.0)
ideal plateau topography consisting of relatively low sloping profiles and the incisions of rivers.

41.1 (66.2) --- Cross White River. --- 24.9 (38.2)

41.5 (66.8) --- Outcrops are Colton Formation. --- 24.5 (37.6)

41.7 (67.1) --- Intersection U.S. Highway 6 and Utah 96. To the south is the mining area of Scofield. --- 24.3 (37.3)

43.4 (69.9) --- Remnants of the former town of Colton. COLTON - Unincorporated - Elev. 7200 ft, 2195 m. Colton was first called Pleasant Valley Junction. In the 1880's it became a railroad camp that last 60 years. Decline and eventual abandonment of Colton came about as diesel locomotives replaced steam driven locomotives. --- 22.6 (34.5)

The Tertiary Colton Formation was named from exposures near the old townsite.

43.9 (70.7) --- Excellent outcrops of Colton Formation. The shapes of the channels can be clearly seen in the outcrop. --- 22.1 (33.7)

44.3 (71.3) --- Cross the Price River --- 21.7 (33.1)

45.4 (73.1) --- Outcrops of the Colton Formation --- 20.6 (31.3)

46.8 (75.3) --- Outcrops of the Colton Formation. This area has a variety of sandstones and limestones that the early pioneers use in the construction of buildings. Some of the sandstones used in buildings in Salt Lake City, namely the county building. From this point, to the east and south, the road will cut into rocks that are Cretaceous in age. Unlike the overlying Tertiary rocks, the Cretaceous rocks were --- 19.2 (29.1) formed along the shores and seaward of an ancient ocean. These rocks are thin to thickly bedded sandstones some of which have some coal associated with them and dark shales. The sandstones were once ancient beaches, or sand islands, or stream channels. The shales represent places where the water was less agitated. Places where mud was allowed to accumulate like lagoons, swamps, and areas further away from shore. See Figures 22 and 23.

48.2 (77.6) --- Utah - Carbon County Boundary. --- 17.8 (26.8)

49.5 (79.7) --- Coal beds can be seen in the outcrops on both sides of the road. --- 16.5 (24.7)

50.1 (80.7) --- The resistant rocks are the sandstones and these makeup the ridges and ledges. The shales are much less resistant and weather to make the slopes between the resistant sandstone ledges as they weather. These resistant rocks are highly fractured and will leave huge boulders and blocks on the shale slopes. This hides the shales and siltstones. --- 15.9 (23.7)

51.3 (82.6) --- Entrance to Price Canyon Recreation Area. The new highway that we drive along is much less threatening than the previous highway. The old highway was located higher on the mountain side, had a high gradient and zig- --- 14.7 (22.8) zagged back and forth. Added to that was many sheer drop offs that made the highway appear quite dangerous to the unpracticed driver (tourist). This proved to be a source of income for the locals in Price, who were paid by the tourists to drive their cars over this menacing stretch of highway.

53.1 (85.5) --- The sandstones here are a series --- 12.9 (20.9)
lenticular beds all put together to make up a big lenticular sandstone layer. These are thought to be examples of ancient barrier islands, much like the modern day Padre island, off the coast of Texas. It is further thought that this part of Utah looked like the Gulf Coast region looked like a few hundred years ago. There were sand islands, deltas, lagoons, and shallow open seas. The shore areas were heavily vegetated and the climate was subtropical.

53.7 (86.5) --- A view of the Castle Gate or Castle rock. --- 12.3 (19.9)

The vertical sandstone walls apparently reminded someone of entrance to a castle, thus the name.

54.2 (87.3) --- Exit to water treatment plant. --- 11.8 (19.1)

54.7 (88.1) --- Coal beds become more evident in the --- 11.3 (18.3)
outcrop. Some of the rock adjacent to the coal beds are red. The reason for this red color is

the rocks were burned or oxidized by the burning coals of the nearby coal beds. Coals can spontaneously burn and clinker the areas above and below the coal beds. Some coal beds have been known to burn for centuries.

55.1 (88.7) --- Entrance to the mines --- 10.9 (17.7)

55.7 (89.7) --- Excellent outcrops showing the sequence of sandstones, shales, and coal. The coal beds here are relatively thin but of high quality. On both sides of the road one can see the red areas where the sandstones are literally baked because coal has caught fire and caused these rocks to oxidize considerably. This firing is sometimes referred to as clinkering. --- 10.3 (16.7)

55.9 (90.0) --- **STOP K** - Observe the coal beds and sandstone layers (Fig. 24). At this stop there can be seen at least four beds of coal, one larger than the rest. The coal rest underneath the sandstone bodies and these are small islands or distributive bars of a delta system that cover up the vegetation material. The coal here is good coal but too thin to mine. --- 10.1 (16.4)

56.0 (90.2) --- Junction of U.S. 6 and Utah Highway 191 --- 10.0 (16.2)

56.5 (91.0) --- Port of Entry Station --- 9.5 (15.4)

57.1 (91.9) --- Cross Railroad --- 8.9 (14.5)

57.3 (92.3) --- Alluvial surfaces that have been dissected by more recent erosion. --- 8.7 (14.1)

57.4 --- (92.4) Helper city limits. --- 8.6 (14.0)

HELPER - Population, 2724 (1980 Census); Elev. 5800 ft. 1768m. Teancum Pratt, with his two wives in 1870 is credited for settling the site that is now called Helper. Pratt used the area for farming and ranching and did some work in developing the nearby coal found in the Createaceous rocks. When the coal mines began to flourish there was an influx of miners from Italy, Greece, Austria, China, and Japan. While coal mining played and still plays an important part in the economy of Helper it was the railroad that added considerable impetus to the economy. In 1892 the site was formally named Helper, in reference to the fact that during the days of the steam engine locomotive, an additional engine was added to trains in order for them to get over the steep grades to the west.

59.0 -- (95.0) The number of sandstone beds increase as we get nearer the ancient shore lines (Fig. 25). This same kind of sedimentary process operates today in places like the Gulf Coast of Mexico particularly near Texas and Louisiana coastal regions. --- 7.0 (11.4)

60.3 -- (97.1) Topography is dominated by the thick shales and thin sandstones. The thin --- 5.7 (9.3)

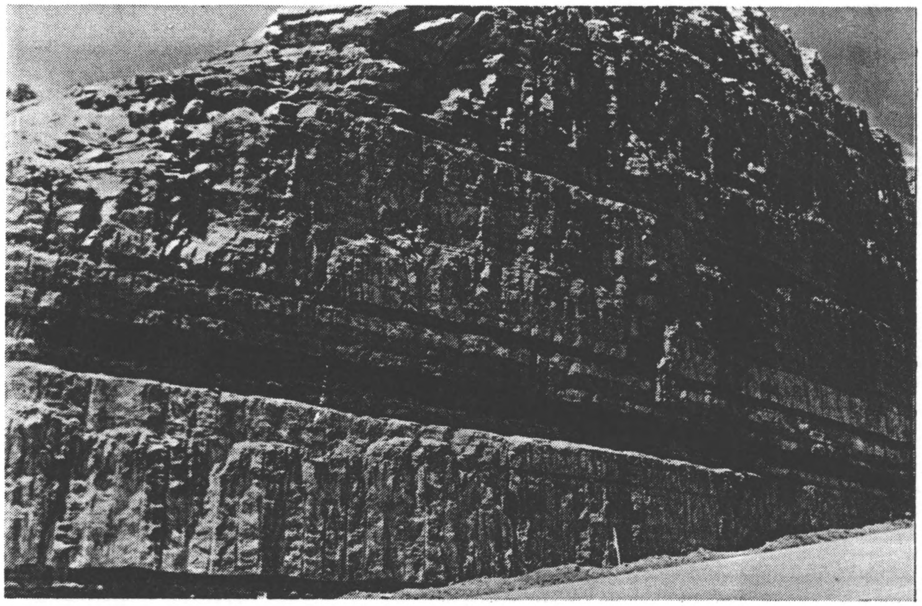


Figure 24 - Thin coal layers in the Blackhawk Formation of the Mesa Verde Group. The coal is formed as a result of quick burial of significant accumulations of plant life that grew in swamps and lagoons behind barrier bars, barrier islands and on deltas of the Cretaceous shoreline. Changes in the sea level were largely responsible for the sand burying these organic rich layers that eventually became the coal layers. Minable coal layers are 3 times or more thicker than the thickest bed seen here.

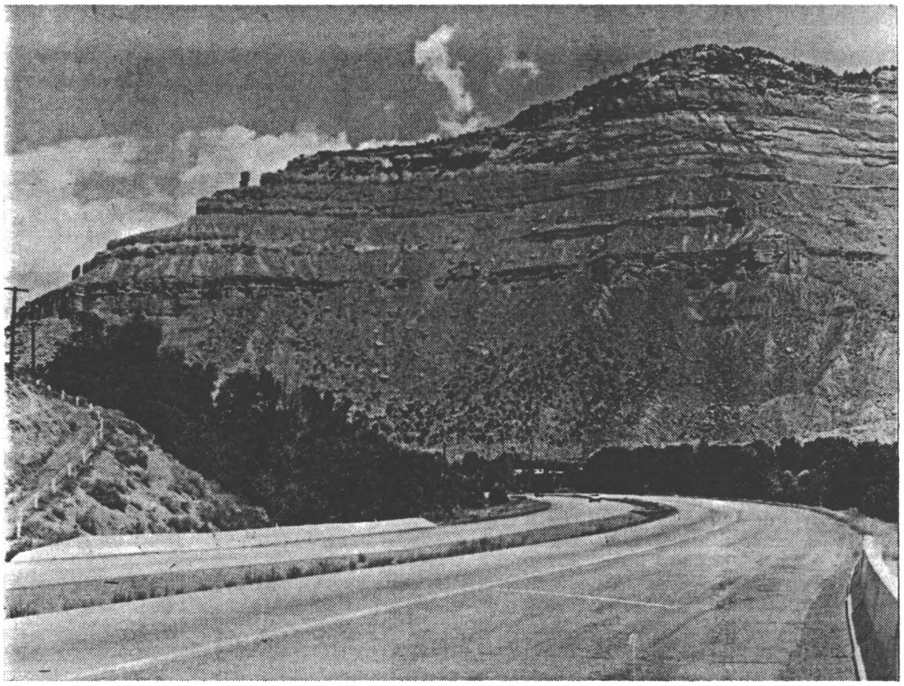


Figure 25 - The entire rock face consists of Cretaceous sandstones and shales. The sandstones are more resistant to weathering and erosion and therefore make prominent ridges. The shales, because they are much less resistant, form slopes and gentle hills. It is thought that the environment in which these rocks formed was much like the modern day Gulf Coast.

sandstones serve as benches while the shales are easily eroded and make slopes or gently rolling hills (Fig. 26).

61.6 (99.2) --- Cross Price River. --- 4.4 (7.1)

61.8 (99.5) --- Cross Highway to Springland --- 4.2 (6.8)

62.4 (100.5) --- Cross Price River --- 3.6 (5.7)

63.0 (101.4) --- Shales that make up the slopes here have --- 3.0 (3.3)
within them volcanic ash beds or bentonites. The bentonites are very useful in determining the age of these rocks. The ashes can be dated by their mineralogy and by using radiometric means to determine how old they are.

64.0 (103.0) --- View to the east show how thick the rock --- 2.0 (3.3)
formations once were. One can get some idea of the huge amount of rock that has been eroded and transported down the Colorado River. This sediment, along with other sediment, was once deposited in the Gulf of California, a transport of approximately 1000 miles. Those sediments are now in the process of making rock.

64.9 (104.5) --- The sandstones here are either beaches or --- 1.1 (1.8)
in some cases barrier islands and as the level of water changed through time the sand would cover over the vegetation which grew behind the bearer islands and therefore that is how the coal would form in many of these cases.

Figure 26 - Outcrops of Cretaceous shales make low, moderate sloped hills. Sandstones make resistant ridges. Much of the low area is underlain by the gray shales which are slippery and sticky when wet.

65.5 --- (105.5) Exit to Price. PRICE - Pop. 9086 (1980 Census) Elev. 5600, 1707m. Price is the Carbon County seat. It has experienced a series of boom and bust cycles associated with the economies of coal mining and processing. Its early history is associated with a small farming operation started by Caleb Rhodes in 1877. The city was organized in 1892 and it is named after William Price, a mormon bishop from Goshen, Utah Valley, who explored the drainage of the Price River in the 1860's. --- 0.5 (0.8)

66.0 --- (106.3) Stop sign at Price exit, turn left to go to Price. --- 0.0 (0.0)

Road Log Price to Spanish Fork Begins at the inter-section of U.S. 6/50 and U.S. 6 and 191 **Miles (Km)**

ROAD LOG ENDS HERE

APPENDIX A - SUGGESTIONS TO TEACHERS

1. Read the road log before you go on the trip. It would be well too, if you could drive the trip yourself before conducting the students.

2. Review the seven concepts with the students before they take the trip.

3. Students may want to take a cloth bag or a small box to carry any rocks or fossils that they might collect. Collections are of more value if the specimens are marked with a felt pen and notes taken on where, and when they were collected.

4. All students should take a note pad and pencil. They should be encouraged to take notes and to make sketches of the geology. These notes can be used as a basis for a field trip report.

5. Small shovels and a few rock hammers would also be useful. Be careful with the use of these tools. Rock splinters from breaking rocks can produce injury.

6. The trip, by bus, should take about 3 hours. If you plan to eat lunch the cafe at mile 28.0 (km 45.1) or the rest stop at mile 29.6 (km 47.7) (Distances from Spanish Fork) are the recommended areas. The trip will be that much longer, but a lunch stop is a good time to reorganize and reorient your group.

7. Be extremely careful with students along the highway. Vehicles sometimes go by at high speed and some may do weird

things when they suddenly see a group of people along the road. Perhaps you would want the bus driver to put on the caution lights while the students are along the road.

Climbing on the rocks can be very dangerous and should be prohibited.

8. This trip takes you through some of the world's finest geology. In order to make the best of it, the students should be prepared. A pretrip overview, doing exercises during the trip, a posttrip review, and an illustrated report are suggested to maximize this educational experience. Students may want to take pictures of the various geologic features for their reports.

In order to assist you the following comments, suggested exercises, and questions for each stop are made available. Stops are designated by letter and correspond to the stops in the road log.

STOP A - This stop is intended to show several important features.

To the west one can see the typical topography of the Basin and Range Province. To the east is the abrupt face of the Wasatch Mountains with the Wasatch Fault at its base. The Columbia Plateau style geology lies directly to the east.

The flat lake terraces are easy to view here. These terraces are the result of rivers bringing in sediment and the lake reworking that sediment to form the terrace. The lake level was at or near that elevation at the time of the terrace development. The Bonneville level is approximately 5090 feet (1554m). The Provo level, just to the west , is the broadest. Unlike the Bonneville level, the Provo level was developed as the lake gradually changed elevation. As a result its elevation ranges over a few 100 feet - generally from approximately 4550 feet (1388m) to 4890 feet (1491m).

The glacial lake that we refer to as Lake Bonneville had a history of waxing and waning. It was a major feature in Utah for over 170,000 years. The Bonneville - Provo shoreline development started approximately 30,000 years ago and ceased about 11,000 years ago.

The triangular facets can be easily seen to the northeast. These triangle shaped spurs of the mountain are thought to be remnants of fault scarps caused by repeated movement along the Wasatch Fault. Students should draw a profile showing the Provo and Bonneville levels.

STOP B - This stop is intended to show how natural geologic features like landslides can affect man's well being. The road log text explains the history of the slide.

Students should view the landslide mass and sketch it. Note the topography of the slide is irregular and hummocky. Eventually the slide will be overgrown with vegetation and yet this topographic style will still indicate the presence of the old landslide.

What conditions or circumstances could reactivate the slide? Answer: Anything that could upset the present equilibrium, such as excavation or a long period of precipitation.

STOP C - The angular unconformity is a bit challenging to see. But the rocks near the road are inclined steeply to the east. The near horizontal Tertiary age rocks can be seen at the crest of the hills. Students should be able to retell accurately the story of geologic activity sequence as shown in figure 10.

Students should be encouraged to sketch the view of the angular unconformity.

STOP D - Many newly opened roadcuts have experienced slope failure and in some cases, landslide. Note the shape of the failed area and the resulting landform.

The students should sketch the slumped feature. Ask what factors contributed to the failure. Answers: Rocks are at a high angle. They are madeup of weakly consolidated silts and clays. They were cut into and creating a very high slope.

STOP E - This tufa cone is the result of several thousand years of deposition from mineral laden groundwater. These types of cones are the direct result of groundwater activity and the groundwater activity is a product of the climate. Scientists can study these deposits and deduct what past climates were like. This information is sometimes valuable in determining climatic patterns of occurrence.

STOP F - These algal balls (Fig. 16) are interesting because they are very good evidence of deposition in a freshwater lake. The calcareous secreting algae grew ont he outside of the foreign object and through time made a series of secretions upon that object. The secretions are often banded in light and dark bands. These bands are suspected to represent seasonal changes in the waters.

Some of these balls can reach sizes of over 10 inches (26 cm) in the long dimension.

Students may collect a variety of these fossils and then classify them according to what made up the object upon which the algae grew.

STOP G - This stop requires much care. Be sure that the students cross the highway safely and that they are aware of the traffic.

This is a rare outcrop of a fault. The fault is a normal fault and both sides of the fault can be seen.

Students should sketch this fault and identify the fault and the identical rock layers that have been separated. This fault is similar to the Wasatch Fault in geometry. Have the students estimate how much the rocks have been displaced. Have them speculate which side of the fault moved, either up or down. (The absolute movement direction cannot be determined. Either one side went up and the other down all the way or each side went part-way up or down).

Ask the students what type of force probably produced this fault. Compression force? (A force directed away from opposite sides) Tensional force? (A force directed toward opposite sides) Answer: Tensional force is the better choice.

STOP H - A series of faults can be seen high on the hillside to the northeast. Have the students sketch these faults and determine which beds are displace. A few pair of binoculars would help view this outcrop.

STOP I - This is an unusually abundant supply of fossil clams (pelecypods), and fossil snails (gastropods), with fragments of vertebrate bones and fish scales.

Have the students first decide which are gastropods and which are pelecypods. Then have them estimate the relative abundance of each.

Another exercise that can be done is to examine the pelecypods and count the annual growth rings on the values. If one counts 10 to 20 of them, then you can determine the average age at death of these clams.

STOP J - There are several stream channels that are preserved in the Tertiary Colton Formation. The one seen here is well preserved (Fig. 20). Notice the shape of the channel. The channel is preserved because it is filled with the sediment it once carried. The stream cut into the muds and through time as channels were filled with sediment and then the stream changed direction the channel was then a candidate to be preserved.

Have the students sketch the channel and have them speculate how the deposit happened to come about.

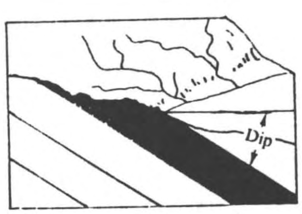
STOP K - These coal beds (Fig. 24) are typical of many of the small coal layers found in the region. Coal bed thickness is the result of accumulations of organic matter and how long that matter accumulated. Some large swamps became the site for major deposits of coal. All coal is the result of burial of accumulated plant debris.

APPENDIX B - GLOSSARY OF SELECTED GEOLOGIC TERMS

Angle of Repose - Angle, measure in the vertical plane, at which unconsolidated or loosely consolidated material can maintain its slope.

Cross-section - A representation of the geology in a vertical slice taken through the rocks. Cross-sections are interpretations of the third dimension of rock geometry.

Dip - Refers to the maximum angle that the rocks are inclined. Most sedimentary rocks are deposited nearly horizontal. After deposition these rocks are often subjected to earth forces that deform or tilt them, thereby causing them to change their angle or dip. Some rocks reach dips of vertical (90°) and some are pushed beyond vertical and become upside down or overturned.

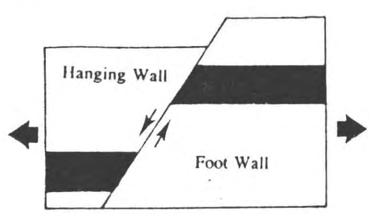


Fault - A fault is a fracture or break in the rocks of the crust along which movement has occurred. Faults are the result of forces acting upon the rocks. There are three general types of faults found on the Earth.

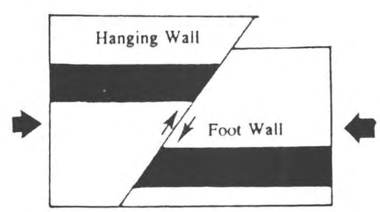
Normal fault - one in which the hanging block appears to have moved down in respect to the foot block. The Wasatch Fault is a classical normal fault. Most normal faults are the result of tensional forces, or forces that are directed away from each other.

Reverse fault - One in which the hanging block has apparently moved up in respect to the foot block. Reverse faults are usually the result of compressional forces, or forces directed toward each other, acting upon the rocks. A reverse fault in which the angle of the fault plane is low to nearly horizontal is referred to as a thrust fault.

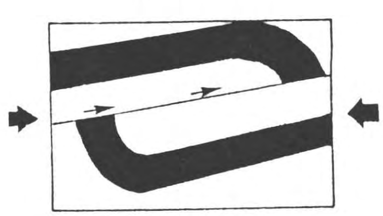
Strike-slip fault - a few faults are nearly vertical and the movement along these faults is one of blocks moving by one another. These faults are referred to as strike-slip. A famous strike-slip fault is the San Andreas Fault. There are strike-slip faults in Utah but they are difficult to discern.

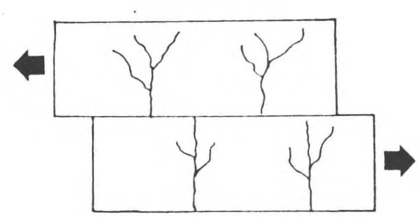


NORMAL FAULT



REVERSE FAULT


THRUST FAULT


STRIKE-SLIP FAULT

Fault Scarp - After there is movement along a fault there develops sometimes a break in the topography. This break is referred to as a fault scarp.

Through time the fault scarp can erode and retreat from the fault that caused it to be. This type of scarp is a fault line scarp.

These features can result in the making of triangular facets as seen at the base of the Wasatch Mountains and seen at Stop A.

Formation - A rock formation is a body of rock, often a series of layers, that have distinctive rock characteristics. To the practiced professional these formations can be recognized and their geologic significance interpreted.

Most formations are named for geographic localities near which they are well developed.

Karst topography - Is a type of topography that develops on horizontal or nearly horizontal soluble rocks, usually limestones. Sinkholes and depressions are common on Karst topography.

Lake Terraces - These landforms are prominently displayed in Utah and can be seen on the west end of this route. These terraces or benches are nearly flat or gently sloping. These landforms form along the edge of lakes and take several hundred to a few thousand years to form.

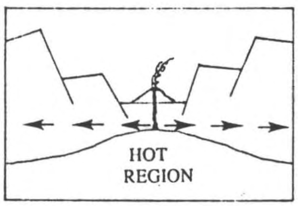
Lake Bonneville had a history of over 165,000 years and during that time the lake level changed, sometimes dramatically. Climatic conditions during the Pleistocene (Ice Ages) is considered to be the cause for this lake.

Great Salt Lake and Utah Lake are remanents of this ancient lake.

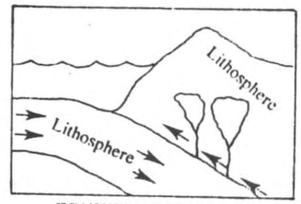
MYA - This is an abbreviation for millions of years ago. This is a common way of indicating the approximate time of occurrence of geologic events or formation of rocks.

Plate Tectonics - The single most important modern concept in geology has been the formulation of the Plate Tectonic model, as a means to explain the geologic features and events experienced on and in the Earth. Basically the model indicates that the Earth's outerpart (lithosphere) is made up of large segments of mostly brittle rock. These large segments, called "plates" are separated from other segments along margins. These margins are zones of earthquake and volcanic activity. These segments, some as large as the North American continent, move about very slowly. These segments can collide with one another, they can pull away from each other, or they can slide by one another. Each of these modes causes the Earth to behave in a respective manner.

The rocks and large scale features we see on this field trip can be put into their suspected plate tectonic setting. For instance, the Basin and Range Province is thought to be the result of these plates pulling apart.



DIVERGENT MARGIN



CONVERGENT MARGIN

Rock Types - In order to help people understand rocks they have been classified according to their suspected origin. Geologists use three main groups of division for rocks, igneous, sedimentary, and metamorphic.

Igneous Rocks are those rocks that originate with once molten rock material called magma. This magma can cool and crystallize below the Earth's surface (intrusive igneous rocks) and thereby make rocks that have big and well formed crystals. Rocks like granite are examples of this type of igneous rock. Other igneous rocks come about as a result of the magma reaching the surface of the Earth, either as a slowly flowing lava or as an eruption or explosion. These rocks (extrusive igneous rocks) can be found as lava flows or as rocks made of fragments. Some very fine fragments, such as volcanic dust, can be spread over wide expanses and become a layer of compacted volcanic dust called a tuff. There are no igneous rocks evident along this route. There are a few tuffs but they require expertise to identify them.

Sedimentary rocks are rocks that originate from ordinary surface processes on the Earth. Rivers, for example, move particles of rock of various sizes along their channel. These particles come to rest in the channel or in a lake or ocean into which the river empties. These particles can become layered as the process proceeds throughout time. The layers can compact and become cemented by mineral bearing waters, thereby becoming a rock that is layered. Some sedimentary rocks are the result of precipitation of mineral material in waters. These rocks, like limestone, are also layered. Sedimentary rocks are also the host rock for most of the fossils found in the world. Sedimentary rocks are common and makeup nearly all the rocks seen on this trip.

Metamorphic rocks are rocks that originate from the intense change, caused by intense heat, and/or pressure, of previously existing rocks. This introduction of heat and pressure can come from deep burial of rocks, from magma activity, or from dynamic pressure caused by plate interaction. There are no metamorphic rocks to be seen along our route.

Unconformity - An unconformity represents a significant break or cap in the geologic record. An unconformity can be thought of as a buried erosional surface. The rocks were deposited or emplaced and then subsequently were subjected to processes of erosion. These rocks were then buried by sediments or igneous rocks thus the buried surface is an unconformity. Unconformities are important surfaces in the geologic record because they often represent dramatic changes in the geological environment of an area.

A significant unconformity is visible at Stop C.

APPENDIX C - ANNOTATED REFERENCES

The text of the roadlog is deliberately oversimplified. For those who would like more detailed information the following readings are called to your attention.

Baer, J.L., 1968, Paleoecology of cyclic sediments of the lower Green River Formation, Central Utah: Brigham Young University Geology Studies, v. 16, pt1 p. 3-96.

A detailed description of the Green River outcrop at mile 19.8 (32.0 Km). The study indicates that the Green River Formation was deposited in a delta and freshwater environment.

Hale, L.A. and Van de Graaff, 1964, Cretaceous stratigraphy and facies patterns, northeastern Utah and adjacent areas: Intermountain Association of Petroleum Geologists Guidebook 13, p. 115-138.

This paper has some interpretative diagrams that show the distribution of certain rock types found on the Price end of the road log.

Hamblin, W.K., 1976, Patterns of displacement along the Wasatch Fault: Geology, v. 4, p. 619-622.

A short paper which well illustrates the interpreted development of fault scarps, and the faceted spurs seen at Stop A.

Hintze, L.F., 1975, Geological Highway Map of Utah, Brigham Young University Geology Studies, Special Publication 3.

This is a beautifully colored map at road map scale with an outline of the geological history of Utah printed on the opposite side. This map can be used alone or in conjunction with Professor Hintze's <u>Geologic History of Utah</u>.

Hintze, L.F., 1988, Geologic History of Utah, Brigham Young University Geology Studies Special Publication 7, 202 p.

This is the most comprehensive reference on the geology of Utah. It is well illustrated and gives an orderly, easy to