THE GEOLOGICAL SURVEY OF WYOMING
Gary B. Glass, State Geologist

GEOLOGIC ROAD LOG OF PART OF THE GROS VENTRE RIVER VALLEY INCLUDING THE LOWER GROS VENTRE SLIDE

by
J.D. Love and Jane M. Love

Reprint 46
1988

Laramie, Wyoming

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Cover: View east from Stop 7, showing rollover of red Chugwater Formation near the southeast end of the Red Hills anticline. White marker beds are gypsum and dolomitic siltstone. (Photograph by J.D. Love, August 26, 1955.)

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Introduction

The rolling landscape on the east side of Jackson Hole is dramatically different from the sheer faces of the Tetons on the west side. The rocks in the Tetons record the oldest two billion years and more of geologic history in the region, whereas the rocks along the Gros Ventre River valley record the youngest 500 million years, including major geologic events during human occupation. The geologic map that accompanies this text **(back pocket)** shows the intricate folds and faults that involve 45 sedimentary units described in the road log. This log also briefly discusses the effects of the rocks and their history on the lives of humans, the environment, the distribution and health of plants and animals, and some aspects of land-use planning.

Tilting and faulting have involved even the youngest alluvial deposits. These faults must certainly have been accompanied by earthquakes. Streams have not had time to adjust to the ever-changing landscape. The rapid erosion of soft strata along the east side of Jackson Hole, the saturation of these strata by melting glaciers, the westward tilting of the area that steepened stream gradients and gave the streams increased cutting and carrying power, and the frequent shaking by earthquakes have resulted in more landslides here than in any other part of Wyoming. Some of these slides have dammed rivers and created lakes such as the Lower and Upper Slide Lakes along the Gros Ventre River. These two landslides occurred in historic time.

The Lower Gros Ventre Slide, one of the largest to occur in modern times in the United States, is a locality of major interest to tourists, geologists, and other scientists. This landslide occurred in 1925 and was followed in 1927 by a flood, when the upper part of the slide was breached by the Gros Ventre River. Several lives were lost, bridges washed away, the town of Kelly was almost obliterated, and there was other extensive property damage. Barry Voight (1978) published a comprehensive compilation of eye-witness accounts and scientific studies of this landslide and flood.

This trip is logged from the junction of Antelope Flats Road and U.S. Highway 89/191/26, in Grand Teton National Park eastward up the Gros Ventre River valley to Crystal Creek. A different return route is logged between the junction of the Gros Ventre Road and Kelly Road, through the village of Kelly and back to the main highway south of Blacktail Butte. The general location of the road log is shown in **Figure 1**. Details of the geology with formation names and ages and the road log route appear on **Plate 1 (back pocket)**.

This log was first printed in the 1987 Wyoming Geological Association Field Conference Guidebook (Love and Love, 1987). The route begins and ends at points on the 1980 Wyoming Geological Association road log (Love and Love, 1980; reprinted as Love and Love, 1983).

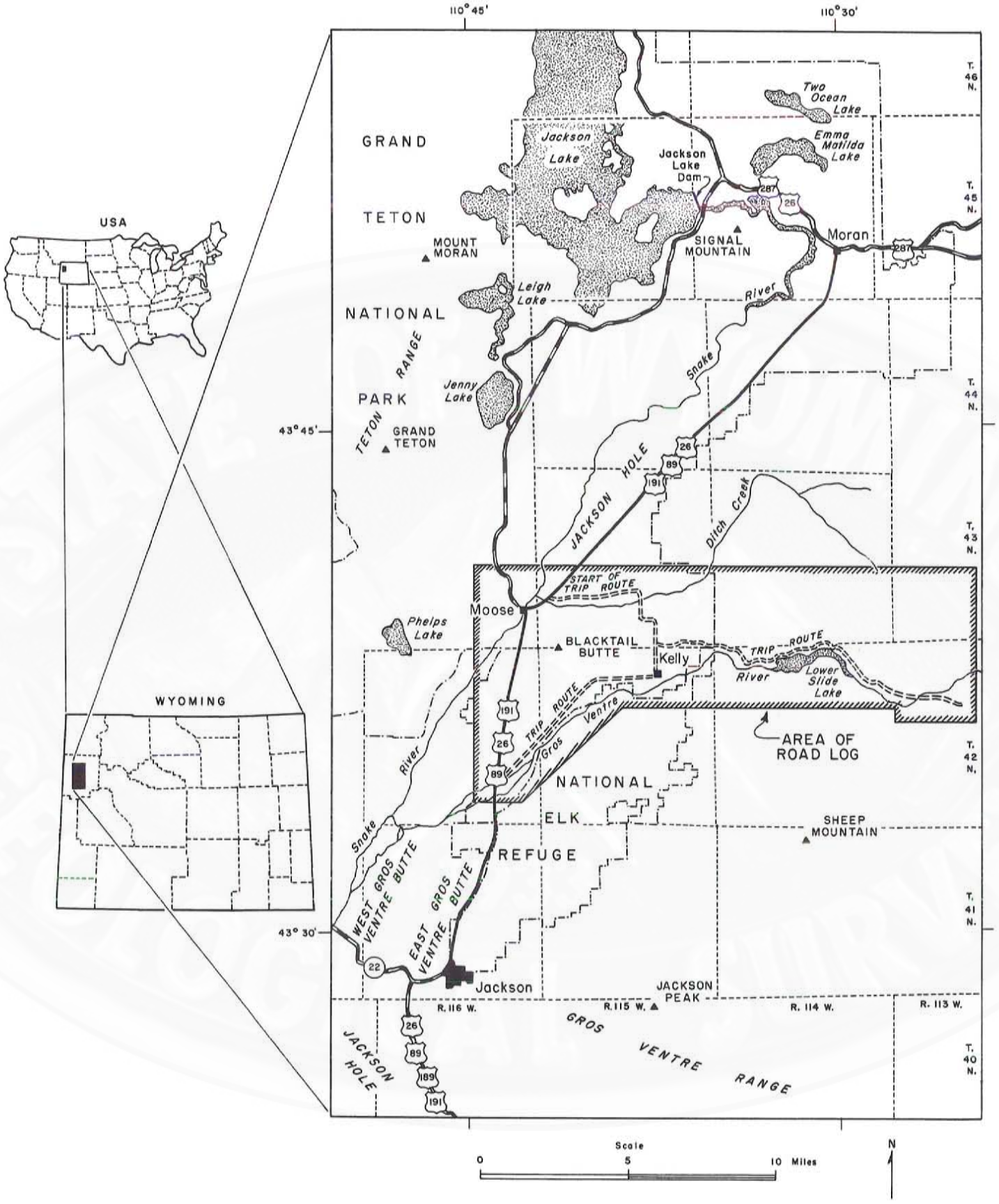

Figure 1. Location map.

Road log

Initial point: Junction of U.S. Highway 89/191/26 with Antelope Flats oiled road, 1.2 miles north of Moose junction, in Jackson Hole, Wyoming.

Distance: First leg – 19 miles; second leg – 8.2 miles.

Roads: Antelope Flats Road, Gros Ventre Road, Kelly Road.

Field stops, first leg of road log:

No. 1 – Kelly Warm Spring – milepoint 6.4.
No. 2 – Overview of stratigraphy at Grand Teton National Park Boundary – milepoint 8.2.
No. 3 – Devils Elbow Slide – milepoint 9.5.
No. 4 – Leidy Formation – milepoint 10.0.
No. 5 – Lower Gros Ventre Slide – milepoint 10.6.
No. 6 – Quaternary deposits, possibly related to a lake created by Devils Elbow Slide – milepoint 11.3.
No. 7 – Red Hills anticline and type section of Leidy Formation – milepoint 15.1.
No. 8 – Overview of geology and turn around point – milepoint 19.0.

Field stops, second leg of road log:

No. 9 – Blacktail Butte – milepoint 3.8.
No. 10 – Teewinot Formation – milepoint 6.0.

Mileage Interval	Mileage Cumulative	First leg of road log
0.0	0.0	Start. Turn east off highway onto Antelope Flats oiled road at sign just north of highway bridge across Ditch Creek. To the south is the north end of Blacktail Butte, a complex fault block that has been scoured, faceted, and overridden by southward-moving pre-Wisconsin ice that was probably 1,000 feet thick on top of the butte. The highest part (west half) of the butte consists of west-dipping white limestone and tuff in the Teewinot Formation (Late Miocene). The east half of the butte is composed of vertical to overturned (toward the west) Paleozoic rocks with ages ranging from Cambrian to Pennsylvanian. The Cambrian rocks are farthest east so this butte cannot be a downfaulted remnant of the east flank of the ancestral Teton Range, but is part of a separate uplift, possibly more closely associated with the Gros Ventre Range to the southeast. The two halves of the butte are separated by a north-trending post-Teewinot normal fault, which coincides with the trace of the older Flat Creek thrust or reverse fault. These are discussed in the second leg of the log. The "Climbers Rock" is a wall of vertical gray Madison Limestone on the northwest corner of the butte, and is used as a practice face for novice rock climbers. Both the east and west sides of the butte are bounded by faults, but their extent, displacement, and ages are not known. The route traverses the northern part of the Ditch Creek fan, the largest alluvial fan in Jackson Hole. This fan emerges from Ditch Creek valley, which is almost straight ahead, and is slightly older than the Antelope Flats glacial outwash plain to the north, as is shown by the fact that the outwash plain cuts into the northern edge of it.
1.7	1.7	Intersection with Mormon Row road coming in from the south. The original farms in this area were established by Mormon families. This was the access road to the town of Grovont, which was located about a mile south and close to the east edge of Blacktail Butte. The pink ranch house on the left was the scene of several events in the movie "Spencer's Mountain". Water for the irrigated farmlands came in part from Ditch Creek and in part from the Gros Ventre River. The Ditch Creek fan, which the route traverses, is about three miles wide in a north-south direction and a little more than three miles long, east-west. It abuts against Blacktail Butte. The eastern part is composed of boulder deposits that are not farmed. The boulders diminish in size westward and are replaced by sands and clays, which support very fertile hay meadows.

1.1 2.8 Pfeiffer homestead on the left, preserved by the National Park Service as an example of how early-day settlers lived. Joe Pfeiffer homesteaded this land in 1910 and built his cabin in 1912. He is reported to have hand-dug a well for water 102 feet deep in 1915. The bottom of the hole was still dusty so he abandoned the effort. He carried water to his cabin from the irrigation ditch for the rest of his life. He died in 1964. His only modern convenience was a battery-powered radio.

The hill on the skyline at 11 o'clock is Shadow Mountain composed of the Teewinote Formation of Late Miocene age, chiefly white lacustrine limestones and tuff beds dipping westward 15-20 degrees under the surface of the Ditch Creek fan.

0.5 3.3 Intersection of two oiled roads. Turn right (south). The road is still on the Ditch Creek fan but aspen groves 0.4 miles north mark the contact between the fan and older loess deposits. At 8 o'clock behind us, in line with Mount Moran (the flat-topped peak with glaciers on the east side), half a mile to the northwest of the road intersection, are tufts of conifers extending out onto the valley floor. These conifers are growing on glacial deposits of uncertain age but probably much older than the fresher-looking deposits along the east front of the Tetons. These conifers grow selectively on the glacial deposits but not on the adjacent fan deposits or loess.

0.8 4.1 Cross Ditch Creek, which is a very small stream to have deposited such an enormous fan. Ditch Creek was so-named because in the 1870s, gold prospectors diverted the water into ditches along the gravelly part of the fan in an unsuccessful attempt to sluice gold from the gravel. Gold is present but not in commercial amounts. These ditches, later surveyed by W.O. Owen after whom Mount Owen was named, indicate the magnitude of this effort.

0.8 4.9 Pass turnoff to Teton Science School and upper Ditch Creek Forest access road. The school is at the mouth of the Ditch Creek valley about two miles northeast of the junction. On the north side of this valley are conspicuous ledges of white freshwater limestone in the Teewinot Formation, dipping westward about 15 degrees. Farther up the Ditch Creek valley, on the skyline, marked by patchy conifers, the rocks are Upper and Lower Cretaceous and Jurassic sandstones and shales on the flanks of the northwest-trending Ramshorn anticline. On the far skyline directly east of the road intersection, the highest prominent point is composed of Pinyon Conglomerate, which here is entirely of Paleocene age. It dips about 5 degrees west and unconformably overlies vertical to overturned Jurassic and Lower Cretaceous rocks. This indicates that the Ramshorn anticline and its southeastward continuation, the Red Hills anticline (**cover photograph**), were formed prior to Tertiary time.

The bare hills in the foreground to the east are chiefly glacial deposits left by ice that moved southward in Jackson Hole and westward from the Gros Ventre River valley.

On the near skyline to the left of the prominent peak of Pinyon Conglomerate is a bare ridge with two conspicuous points on it. This ridge is a unique moraine composed primarily of boulders of Tensleep Sandstone. The age of this moraine and its relation to the Tensleep Sandstone outcrops in the adjacent Gros Ventre Range have not been determined. The low terrace marking the southeastern boundary of the Ditch Creek fan is underlain by quartzite boulder outwash gravel capped by very fertile loess which has been farmed. These relationships indicate that the fan is younger than the loess and the outwash gravel. The age of the loess has not been determined here, but similar loess six miles to the southwest has a ^{14}C age of 13,000-19,000 years.

To the southeast is the prominent scar of the Lower Gros Ventre Slide, which cuts through the timbered skyline ridge. This and the strata in the closer hills are discussed later. The prominent bare knob on the skyline to the southeast is Sheep Mountain, which is composed of Madison Limestone at an elevation of 11,239 feet. Directly south is Jackson Peak, elevation Directly south is Jackson Peak, elevation 10,741 feet, the pyramid-shaped peak composed of Precambrian granite, probably about 2.5 billion years old, and capped by a remnant of Flathead Sandstone of Cambrian age. These and adjacent skyline ridges mark the western part of the Gros Ventre Range.

The aspen-covered ridge in the intermediate distance to the south and the mountains on the skyline to the southwest are discussed later. Blacktail Butte, three miles to the southwest, rises 1,000 feet above the valley floor (from 6,600 to 7,688 feet). Almost all the rocks visible on the steep east face are Paleozoic, with Cambrian strata exposed on the lower slopes and the Madison Limestone at the top, as was discussed earlier. At the break in slope between the Ditch Creek fan and the steep east face of Blacktail Butte, in line with the highest part of the butte, talus deposits at the foot of a prominent torrent gully are downfaulted, apparently along a Holocene fault. The complex geology of the southeast spur of the butte is discussed later from a closer vantage point.

0.5 5.4 Contact between the south edge of the Ditch Creek fan and light colored loess deposits is in road cut at left. At this point the relationship of the fan, not only to the loess, but also to the Gros Ventre River floodplain to the south, can be seen. The fan deposits merge with the floodplain about one-fourth mile to the south.

0.5 5.9 Junction with Gros Ventre Road. Turn left (east). The second leg of this road log will pick up at this point and continue to the south. A few hundred feet northeast of the junction is a lumpy hill of glacial debris overlain by outwash gravel and loess.

0.4 6.4 **STOP 1.** Kelly Warm Spring. This spring flows an estimated five million gallons per day of slightly sulfurous water with a maximum temperature of 86°F (30°C). Many small seeps of nonflammable gas emerge throughout the pool and keep the surface agitated. No analyses of the gas have been made. This is a favorite collected for analysis were lost. This is a favorite place for kayak training and swimming. The pool contains a varied aquatic fauna, including guppies, several species of mollusks, and stick-like micro-organisms of uncertain affinity. The water emerges along a Holocene or Pleistocene fault that displaces glacial debris of uncertain age, but probably old. At the bend in the oiled road 100 feet north of the pool is a ledge of travertine deposited by water of some earlier stage of hot spring development about 10 feet above the present orifices. This is the northernmost of two warm springs in the area. The other comes up along this same fault, a mile to the southeast at Teton Valley Ranch, on the south side of the Gros Ventre River.

At Kelly Warm Spring the Holocene or Pleistocene fault splits. One part extends about two miles to the northeast, with the southeast block down. It offsets loess and older glacial deposits. The other part extends along the break in slope to the northwest and southeast. On the east side of this fault, southeast of the spring and underlying the glacial deposits, is the Teewinot Formation, which dips westward 10-20 degrees.

0.7 7.0 "Shane Cabins" on the left. These cabins were originally built by homesteader Johnny Erwin and occupied by Luther Taylor between 1923 and 1948. The land was acquired by Grand Teton National Park in 1956. The stampede scene in the movie "Shane" was filmed here.

1.2 8.2 **STOP 2.** Turnout on right 100 yards east of Grand Teton National Park Boundary. The big cliff to the west on the north side of the Gros Ventre River within the Park is the Tensleep Sandstone capped by a thin ledge of phosphatic chert in the basal part of the Phosphoria Formation. Downstream from this outcrop is a regular section of Amsden Formation (marked by red shale) and gray cliffs of Madison Limestone. White beds on the skyline unconformably overlying the red Amsden are the basal conglomerate of the Teewinot Formation. On the north side of the highway here are poor exposures of the Phosphoria, tawny Dinwoody, and red Chugwater Formations, capped by bouldery debris left by southward-moving ice in Jackson Hole, which merges here with westward-moving ice from the Gros Ventre River valley. Some of the boulders, as large as a station wagon, are of Huckleberry Ridge Tuff that originated in Yellowstone National Park, about 50 miles to the north. Some smaller erratics are granite from the Wind River Mountains about 50 miles to the southeast. Apparently, the southward-moving ice was dominant and dammed up the Gros Ventre River valley at this point, causing the development of a lake at least 30 miles long within the valley. At that time the valley had a topographic configuration almost the same as it is today. Remnants of the sedimentary deposits in this lake are discussed as the route crosses them. Directly south of the stop, the flood channelway of the Gros Ventre River, created in 1927 when the Lower Gros Ventre Slide was breeched, can be observed most of the way to the next stop.

0.7 8.9 Cross Turpin Creek, named after Dick Turpin (1840-1919), a Civil War scout who came to Jackson Hole, reportedly with stolen mules, in 1888. One of the original pioneer roads coming into Jackson Hole from the east went down Turpin Creek.

0.1 9.0 Entrance to Flying V dude ranch. Many famous people, including Senator Sam Nunn and writer John McPhee, have stayed here. Northward, up Turpin Creek, are salmon-pink cliffs of Nugget Sandstone overlying the red Chugwater Formation. The Nugget is about 100 feet thick here but pinches out five miles to the north on Ditch Creek.

0.2 9.2 Black exposures on left are Retort Shale Member in the upper part of the Phosphoria Formation. The shale contains thin beds of phosphorite and small amounts of trace elements such as gold, silver, vanadium, uranium, zinc, selenium, etc. Overlying the black shale is a chert bed capped by evenly layered phosphatic sandstone that marks the top of the Phosphoria Formation.

0.3 9.5 **STOP 3.** Turn right into the parking area. This is the site of the Devils Elbow Slide, which can be seen directly to the south across the Gros Ventre River. This slide involved the Tensleep Sandstone and pink shales in the underlying Amsden Formation, as did the Lower Gros Ventre Slide, a mile to the east. Blocks of Tensleep Sandstone border the parking area

so the Devils Elbow Slide must have crossed the river and may have dammed it up to the present road elevation. Although it did not start as high up the mountain slope as the Lower Gros Ventre Slide, the Devils Elbow Slide is much wider, more than a mile east-west. It extends to the Lower Gros Ventre slide on the east, and includes the slope all the way to the near horizon on the west. The ledges directly below the turnout are Tensleep Sandstone, which was overridden by slide debris. The fresh unvegetated inner gorge of the Gros Ventre River was scoured out by flood waters when the upper part of the Lower Gros Ventre Slide washed out in 1927. The Devils Elbow Slide impounded a lake, on the north margin of which is a remnant of lacustrine carbonaceous debris preserved in a road cut.

On the north side of the road at Stop 3, and extending up the spur to the north, is a section of the Leidy Formation (formal name reserved in manuscript submitted May 23, 1985) of Quaternary age, about 300 feet thick. This sequence, overridden by landslide debris, consists of interbedded fluviatile and lacustrine sands, clays, and glacial debris, all of Pleistocene age. These are discussed in more detail at the next stop and are shown in **Figure 2**. One of the consistent characteristics of the Leidy Formation is the presence of a significant amount of selenium.

The poisonous selenium indicator and converter plant *Astragalus bisulcatus*, the two-grooved milk vetch that requires selenium to grow and that converts it to a form available to other plants, can somtimes be seen in greater abundance at the turnout on the right side of the road at mileage 9.7. Cattle and other animals eating this plant and contaminated grasses around it are affected by chronic selenium poisoning.

0.5	10.0	**STOP 4.** Park on right side of road. **Figure 2** is a diagram showing the intertonguing relations of lacustrine, fluviatile, and glacial debris in the lower part of the Leidy Formation on the south-facing exposures in the road cut. At the eastern end of the road cut, the Leidy Formation rests unconformably on the Triassic Dinwoody Formation. Farther east around the bend in the road are good exposures of the red siltstones and sandstones in the Red Peak Member of the Chugwater Formation.
0.3	10.3	Landslide debris from the Lower Gros Ventre Slide is plastered against red Chugwater Formation.
0.2	10.5	Turnoff to Taylor Ranch on right.
0.1	10.6	**STOP 5.** Lower Gros Ventre Slide (**Figure 3**), turnout, exhibit, and explanation. Many papers have been written on the history of this slide and the subsequent flood. An historical paper by E.W. Hayden and a geological account by Keefer and Love are in the Wyoming Geological Association Guidebook for 1956. By far the most comprehensive study, however, with many photographs, diagrams, historical accounts, and an extensive bibliography of both published and unpublished data, was assembled by Barry Voight (1978). He considered this to be the largest (various estimates of 20 to 50 million cubic yards of debris have been made by others) slide of historical record in the United States.

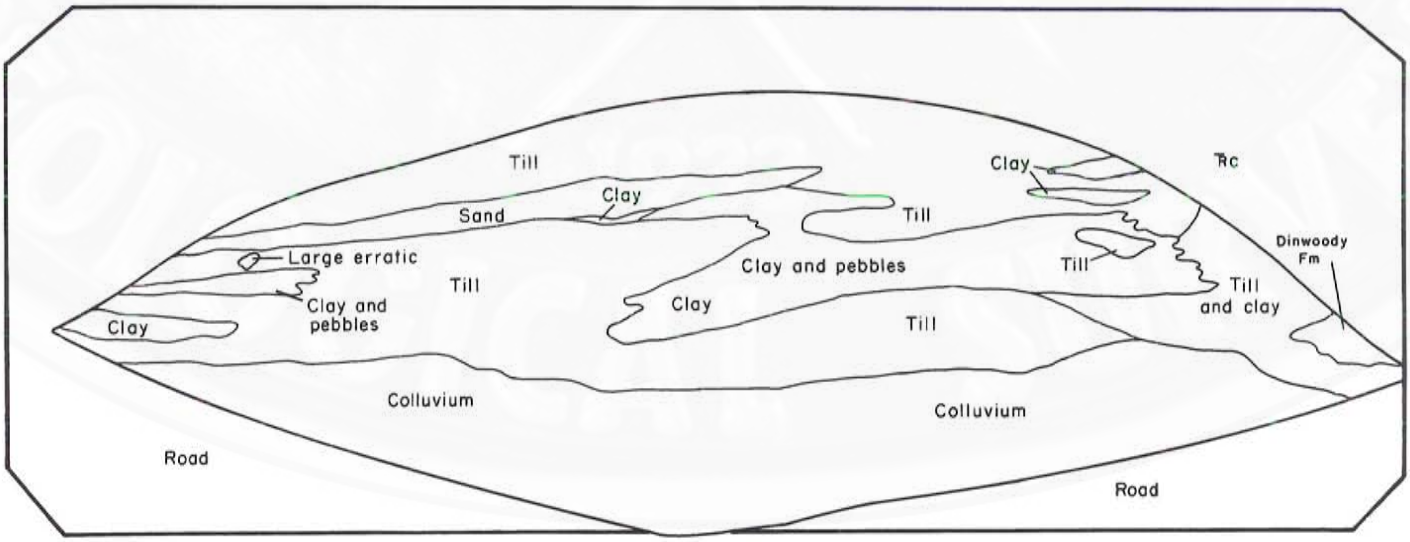

Figure 2. Diagram of the south-facing side of the road cut at Stop 4, showing the intertonguing relations of lacustrine, fluviatile, and glacial deposits in the Leidy Formation of Pleistocene age. The till contains abundant striated and soled erratics, chiefly of quartzite and Paleozoic and Mesozoic rocks. The clay is green and brown, commonly has sporadic pebbles, but is very fine grained. The sand is tan and unlithified. On the sand bed at the upper left, strike is about 30°E., dip 7°NW. (Diagram is sketched from a photograph by J.D. Love, August 6, 1984.)

Figure 3. Areal-oblique view south at the Lower Gros Ventre Slide. Pink shale in the Amsden Formation overlain by the hard Tensleep Sandstone exposed in place on the left side of the slide scar. Untimbered outcrops at the far left are Phosphoria and Dinwoody formations. The rounded summit at the top center is the chest part of the "Sleeping Indian", composed of Madison Limestone. A highly seleniferous remnant of the Leidy Formation is along the Gros Ventre road at the bottom right. (Photograph by W.B. Hall and J.M. Hill, June, 1955, almost exactly 30 years after the slide was emplaced.)

The Hebgen Slide of 1959, nearly 100 miles to the northwest, had an estimated volume of 37 million cubic yards.

To summarize, the Lower Gros Ventre Slide occurred June 23, 1925, on the site of older slides. The debris was emplaced in about three minutes and probably was triggered by an earthquake. The momentum of the slide carried debris as much as 350 feet up the north side of the valley and created a lake about 200 feet deep and three miles long. On May 18, 1927, the top 50 feet of the dam washed out and lowered the lake that much, causing a flood downstream (described in the second leg of this road log). The pink shales along the sides of the slide **(Figure 3)** are in the Amsden Formation, which is capped by the hard gray Tensleep Sandstone, fragments of which are in the exhibit area. Directly southeast of the outlet of the lake are unvegetated outcrops of black shale in the Retort Member of the Phosphoria Formation. About 100 feet northeast of the exhibit area on the north side of the road at eye level is a pink and gray cliff of the gypsiferous Alcova Limestone Member of the Chugwater Formation. The stratigraphy of the overlying rocks is discussed later.

0.3	10.9	Purple shales on the left side of the road are in the Popo Agie Member of the Chugwater Formation, overlain by the salmon-pink Nugget Sandstone.

0.4 11.3 **STOP 6.** Pull out on right (south) side of road. The badly-slumped road cut on the north side of this road is the site of the ^{14}C samples referred to at Stop 4. A sample of wood fragments associated with high-spired snails, probably lacustrine, three feet above road level yielded an age of 3,790 ± 250 years (U.S. Geological Survey sample W2458, Meyer Rubin, written communication, 1969) (**Figure 4**). A second sample 9 feet above this, of land snail shells, yielded an age of 4,120 ± 200 years (U.S. Geological Survey sample W2432, Meyer Rubin, written communication, 1969). These sediments are slightly lower in elevation than the top of the Devils Elbow Slide and may have been deposited along the north margin of the lake impounded behind that slide.

From here on to the east, road cuts are in red and green shales in the Sundance Formation, which is so prone to sliding that road maintenance is difficult. The fluted ledges 200 feet above the road to the north are the basal sandstones of the Cloverly-Morrison (?) sequence. Younger stratigraphic units are described from vantage points farther east.

0.5 11.8 A northeast-trending normal fault repeats Nugget Sandstone on left.

0.1 11.9 Atherton Creek Campground on right. "Old Man Atherton" was a pioneer settler in the valley. The road to the east curves around a large slide that moved southward before the Lower Gros Ventre Slide was formed.

0.2 12.1 View straight ahead shows an unfaulted section of Middle and Upper Jurassic and Lower Cretaceous rocks. At the base of the lowest pale green ledges is the contact between the "Upper Sundance" and the Cloverly-Morrison (?) sandstones. The varicolored claystones higher in the section are in the middle part of the Cloverly Formation. The "rusty beds" sequence is the upper unit in the Cloverly and makes the prominently stratified brown cliffs. On the far skyline, in line with these rusty cliffs, is the Mowry Shale of Early Cretaceous age. On the eastern skyline is the red Chugwater Formation on the Red Hills anticline.

Figure 4. View north across Gros Ventre Road at Stop 6, showing a 22-foot measured section (at the time it was fresh) of a remnant of thin-bedded fine-grained clay and sand containing abundant carbon trash, several species of mollusks, and some bison bones. These are thought to be deposits that accumulated along the north margin of a lake impounded behind the Devils Elbow Slide. Indicated are horizons of high-spired bog snails and carbon trash that yielded a ^{14}C age of 3,790 years (A), and the land snail Helix *that yielded a ^{14}C age of 4,120 years (B). Note shovel for scale. A quartzite gravel layer is at the base of the sequence just above road level. The fluted cliff at the top of the photograph is the basal sandstone of the Cloverly-Morrison (?) sequence. (Photograph by J.D. Love, September 26, 1969.)*

1.5	13.6	Cross Horsetail Creek. The preceding 1.5 miles of road is entirely on landslide debris.
0.1	13.7	Flying Goose Ranch Road to right. Across the Gros Ventre River to the southwest is the Red Slide, which involves the plastic red and purple shales in the Popo Agie Member of the Chugwater Formation and the overlying salmon-pink cliff-forming Nugget Sandstone. The Red Slide is slow-moving and was triggered by saturation of the toe by water from Lower Slide Lake. It is still moving and has almost pinched off the east end of the lake.
0.2	13.9	The lumpy hill extending south into the valley on the left side of the road is a remnant of the Leidy Formation.
0.4	14.3	Approximate contact of Leidy Formation on the east and alluvial debris on the west.
0.8	15.1	**STOP 7.** Park on right (south) edge of turnout at sharp bend in road. This is the best view in the region of the Red Hills anticline in the Chugwater Formation (**cover photo**). The light colored layers within the red are gypsiferous siltstones that emphasize the rollover of strata from the gentle northeast flank to the vertical southwest flank. There may be a thrust fault along the southwest margin. Two dry holes were drilled for oil near the crest of the anticline, up the steep canyon north of the Gros Ventre Road. Both went to the Madison Limestone. Minor amounts of oil staining were found in the Tensleep Sandstone. The Ramshorn anticline is a northwest continuation of the Red Hills anticline. Both are pre-Tertiary in age, as is shown by the fact that the Pinyon Conglomerate, which here is of Paleocene age, is not involved in the folding (see discussion at milepoint 4.9). On the far skyline to the northeast are the salmon-pink ledges of the Nugget Sandstone capped by the pink Gypsum Spring Formation and greenish gray Sundance Formation. The stop is on the type section of the Leidy Formation (**Figure 5**), which here is about 440 feet thick.

The upper half is chiefly reddish brown to gray very fine-grained clay. Sands become more abundant in the lower half and there is a 50-foot

Figure 5. View north across the Gros Ventre River, showing the type section of the Leidy Formation at Stop 7. Indicated are landslide debris derived from the Leidy Formation (Qls); Leidy Formation (Qly); Cloverly and Morrison (?) Formations (KJm); Nugget Sandstone (JTrn) and Chugwater Formation (Trc). (Photograph by J.D. Love, June, 1963.)

gold-bearing quartzite gravel at the base where it rests unconformably on the Morrison (?) Formation. The two trees 100 yards to the north (**Figure 5**, arrow) are on a till containing boulders of granite from the Wind River mountains 45 or more miles to the southeast. This till intertongues with fluviatile sand and very fine-grained laminated lacustrine clay (**Figure 6**). Many of the clay beds are highly seleniferous and support thick stands of *Astragalus bisulcatus*. The lumpy topography to the right of the red butte in the middle of the valley to the southeast marks a series of moraines of the youngest glacial stage in this area. These emerge from the Gros Ventre Range and extend almost to the river. The linear breaks crossing the field directly to the east are thought to be Holocene fault traces. They offset the modern southward-flowing drainages. Directly to the south across the Gros Ventre River is a sharp ridge parallelling the river. This is part of an enormous landslide that skidded northward off dip slopes of the Gros Ventre Range and involved Jurassic and Lower Cretaceous strata. Grizzly Lake (not visible) is impounded behind this landslide barrier.

1.0 16.1 Entrance to Red Hills Ranch on right. On far skyline to southeast, uppermost salmon-pink cliff is Nugget Sandstone.

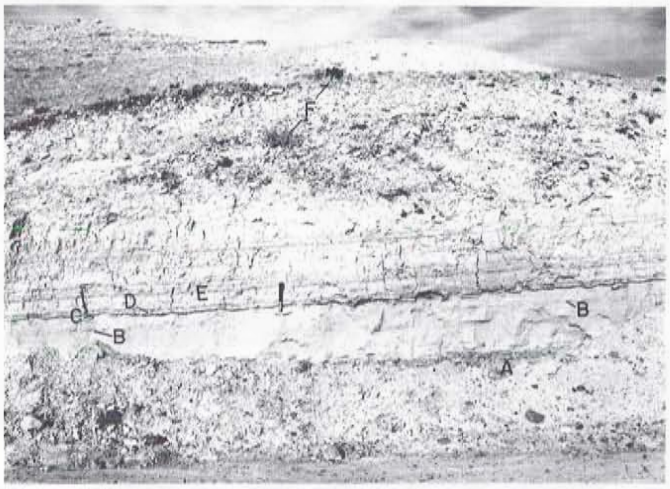

Figure 6. Exposure of lacustrine and fluviatile strata in lower part of type section of Leidy Formation just west of Stop 7. Indicated are quartzite gravel (A); sand with lenses of coaly debris (B); dark gray marker claystone that is continuous for at least 100 feet (C); varved pink, yellow, and gray claystone (D); sand and silt (E); and selenium converter plants of Astragalus bisulcatus *(F). Hammer shows scale. (Photograph by J.D. Love, September 26, 1969.)*

0.8 16.9 Gros Ventre River bridge. On the northwest side of the river is a section of the Chugwater Formation 1,210 feet thick. For thicknesses and lithologic descriptions of this and other formations in the area, see Love and others (1951a and 1951b). These red cliffs are a favorite winter habitat for bighorn sheep. Some remain here until June.

0.4 17.3 Hill on right along road is the basal conglomeratic part of the Leidy Formation with a thick mantle of younger glacial debris.

0.2 17.5 Entrance to Red Hills Campground on left.

0.4 17.9 Entrance to Crystal Creek Campground on left.

0.7 18.6 Crystal Creek bridge. Note that the water in Crystal Creek is much clearer than that of the Gros Ventre River. This is because there is no Cretaceous shale in the entire Crystal Creek drainage area.

0.4 19.0 **STOP 8.** End of this leg of road log. Turn vehicles around. Road to south goes to Red Rock Ranch. From this site much geology can be seen in all directions. On the far skyline to the north, the three prominent humps are Mount Leidy (on the left), Middle Leidy, and East Leidy. All three are composed of more than 1,000 feet of gold-bearing Pinyon Conglomerate, which here is entirely of Paleocene age. These three peaks are drained by Slate Creek, which enters the Gros Ventre River at the base of the gray hills to the north-northeast. A huge landslide, chiefly of Lower Cretaceous shales, comes into the drainage area from the west and has shifted the course of Slate Creek eastward against these hills. Another huge landslide, called the Lavender Slide, for obvious reasons, is to the northwest and extends all the way to the Gros Ventre River (**Figure 7**). It involves the variegated claystones in the Cloverly Formation and the green plastic shales in the Sundance Formation.

The stratigraphic sequence visible to the west, north, and east is as follows (**Figure 7**). To the west is the red Chugwater Formation, overlain on the high hills by the salmon-pink cliff-forming Nugget Sandstone. This is overlain by the red Gypsum Spring Formation and the greenish gray Sundance Formation. The lower sandstones in the Cloverly-Morrison (?) sequence are not easily distinguished in this view but are at the base of the light-colored variegated middle member of the Cloverly Formation. Above the variegated strata are the "rusty beds", rusty brown thin-bedded sandstones comprising the uppermost part of the Cloverly Formation. Above the "rusty beds" is the soft black

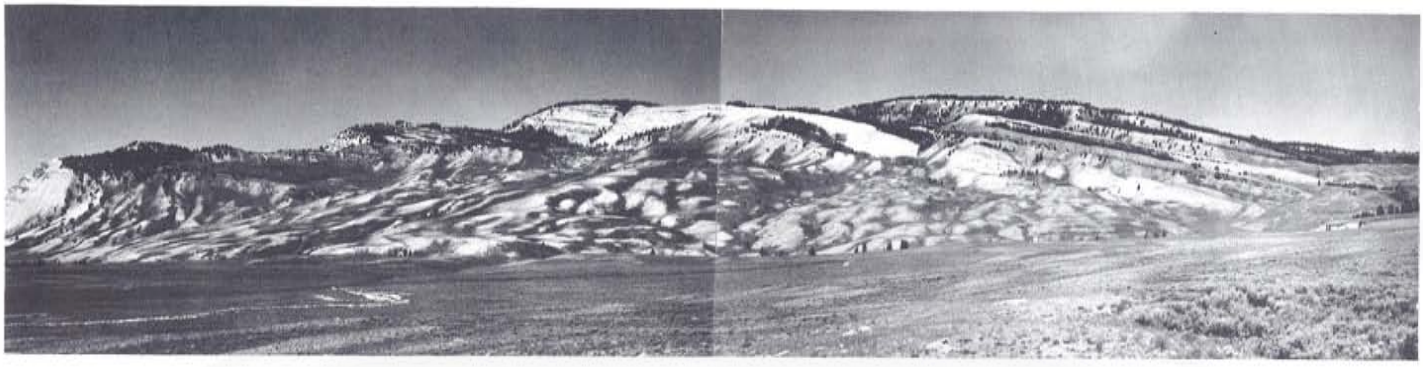

Figure 7. View of Lavender Slide, looking northwest across the Gros Ventre River. The Chugwater Formation is at the extreme left; the Cloverly Formation is in the center, overlain in order by the Thermopolis and Mowry Shales and the Frontier Formation on the right skyline. (Other units described in text, Stop 8.) The Crystal Creek lateral moraine is in the right foreground. (Photograph by J.D. Love, August 26, 1955.)

Thermopolis Shale, about 150 feet thick. It is capped by the Muddy Sandstone Member 40-70 feet thick. On the far skyline to the north the gray beds are the Mowry Shale capped by the basal sandstone in the Frontier Formation. To the northeast, the lower slopes in the gray hills are the lower part of the Mowry Shale. In the exposure to the east, the basal sandstone in the Frontier is the pale tan sequence between the two white layers. The Frontier Formation extends all the way to the skyline point to the east and is about 1,000 feet thick.

Just above the road level to the southeast, the lumpy topography is on the Crystal Creek lateral moraine, the youngest on the valley floor in this area. In line with the highest part of this moraine and about 50 feet above the level of the outwash plain are several very fresh kettles presumably formed as ice melted out underneath. These have vertical margins. One was known to have collapsed within the last 25 years when one of Senator Clifford Hansen's bulls broke through the surface turf (rescued intact).

The glaciated valley of Crystal Creek is directly south of the stop. On the east side is a regular stratigraphic section with the Madison Limestone at creek level and the Nugget Sandstone forming the pink cliff near the high point. The Amsden, Tensleep, Phosphoria, Dinwoody, and Chugwater Formations are in between. A measured section of these is in Love and others (1951b). The cliffs along the sides of Crystal Creek Canyon are the sites of prehistoric Indian shelters. The smooth grassy upland in line with the Nugget Sandstone cliff is a remnant of the Leidy Formation, the top of which is nearly 1,000 feet above the present valley floor. On the far skyline at the head of Crystal Creek is Crystal Peak, composed of Madison Limestone. West of Crystal Peak, all of the skyline peaks are likewise of Madison Limestone. The upland grassy plateau west of Crystal Creek, and at about the same elevation as the plateau on the east side, is underlain by another remnant of the Leidy Formation. The lower level of lumpy topography is on a lateral moraine.

Directly to the west, almost in line with the road, is a fan-shaped landslide that extends downslope to the Crystal Creek bridge. This slide is composed chiefly of plastic clay in the Leidy Formation and is still moving. The top is at the prominent pull-away scar near the top of Red Butte. From the scar to the top is red Chugwater Formation. The topographic relief on the base of the Leidy Formation here is 660 feet in a horizontal distance of 2,500 feet. The position of these remnants of the Leidy Formation demonstrates that at the time it was deposited, the general configuration of the Gros Ventre River valley was much as it is today and that there was very little later deepening of the valley floor. The Lavender Slide and the Crystal Creek terminal moraine abut at the site of the present Gros Ventre River channel. These emplacements, which probably occurred more or less contemporaneously, dammed the river and a lake was impounded.

Meltwater from the ice in the Mount Leidy area flushed gold-bearing quartzite gravel down Slate Creek and into the lake behind the moraine-landslide dam. Gold was thus concentrated at this site in these gravels. Many attempts have been made in the last hundred years to

retrieve this gold. The latest was in the 1960s by Westinghouse Corporation. A two-story elaborate "mill" was constructed but it was not geared to recover such fine-grained gold so the project failed and all that remains is a vandalized orange dragline.

Retrace route to Kelly Road junction at milepoint 5.9. Reset both interval and cumulative mileages at zero.

Mileage		Second leg of road log
Interval	Cumulative	
0.0	0.0	Turn south on Kelly Road.
0.1	0.1	Cross irrigation ditch. The combined outflow from Kelly Warm Spring plus Gros Ventre River water is estimated to be about 12 second feet per day (7.7 million gallons per day). This is the site where snail shells were collected from a white marl in the bottom of the ditch for ^{14}C age determination (data not available at the time of this writing). When the age is determined it should date the development of the flat area to the south between here and the Gros Ventre River. The south-trending upland swales 500 to 1,000 feet up on the far hillsides to the southeast are giant grooves cut in Paleozoic rocks by southward-moving pre-Wisconsin ice.
0.9	1.0	Entering village of Kelly. Turn right (west). This village was established by W.J. Kelly in 1909. All buildings except the school and church were destroyed in 1927 when the top 50 feet of the Lower Gros Ventre Slide gave way. A wall of water about 15 feet high raced through Kelly, which at that time had 80 inhabitants. Six people drowned. The Snake River, below its junction with the Gros Ventre River, locally rose as much as 50 feet; the town of Wilson was flooded by six feet of water and extensively damaged. Flooding extended downstream as far as Idaho Falls, 135 miles away. Directly east of Kelly is the mouth of the Gros Ventre River canyon. On the north side, white beds are in the Teewinot Formation, dipping about 12 degrees northwest. On the south side, gray ledges are Madison Limestone, dipping about 17 degrees northwest. The Teton Valley Ranch warm springs emerge along the contact of the Madison Limestone and alluvium on the south side of the river. The springs emerge from several orifices, probably along a continuation of the same fault as that at the Kelly Warm Spring, but the water is somewhat cooler, having a maximum temperature of 72 degrees F (23 degrees C). The water from some of the orifices is slightly more sulfurous than that at Kelly. Nonflammable gas is abundant. The Flat Creek fault, which is a high-angle reverse or thrust fault, traverses the base of the high wooded slope to the southeast of Kelly, in line with Sheep Mountain, and cuts westward beneath the alluvium, under the town of Kelly, and across the valley to the south edge of Blacktail Butte where it is exposed again. The displacement is estimated to be several thousand feet, down on the south and southwest. Later normal faulting along the same trace on Blacktail Butte puts the Teewinot Formation against Paleozoic rocks. This fault dies out southeastward up Flat Creek valley, the head of which is marked by the low notch in the skyline. The northwestern extent is discussed in connection with the structure of the south end of Blacktail Butte. The lumpy hills directly south and southwest of Kelly are all part of the type Teewinot Formation. The north-tilted, planar, timbered surface to the left of Jackson Peak on the southern skyline truncates north-dipping Paleozoic rocks ranging in age from Cambrian to Permian. This tilted surface may represent the upper limit of Tertiary fill along the western margin of the Gros Ventre Range.
1.1	2.1	The view north and west from this milepoint shows the extremely flat surface of the floodplain south of the Ditch Creek fan and west of the mouth of the Gros Ventre River canyon. This surface terminates westward at a series of small fault scarps that extend along the east face of Blacktail Butte and continue southward toward the Gros Ventre River. Just above eye level at the base of the butte, two alluvial cones at the foot of torrent gullies can be seen offset by Holocene faults. Details of the structure of Blacktail Butte are discussed at the next stop, but from this perspective the down-dropped southeastern spur of the butte can be seen a little differently. The fault along which this displacement occurred is in the valley between this spur and the higher part of the butte to the north. This spur consists of west-dipping Teewinot Formation overlying Bighorn Dolomite just above the valley floor. The bare fluted slopes on the south-facing part of the butte are slip-off glaciated slopes carved by southward-moving ice that overrode the butte, and that also scoured the east and west faces of it.
1.1	3.2	Road junction. Road to north goes along Mormon Row, described in the first part of the road log at milepoint 1.7. The village of Grovont was located half a mile to the north at the east base of the down-faulted spur. The village was obliterated when the Park Service bought the land.
0.4	3.6	Road to left is entrance to Gros Ventre Campground.
0.2	3.8	**STOP 9.** Park facing Blacktail Butte. From here the complex structure of the south face of the butte is visible. As described earlier, at the extreme southeast corner of the butte, the

Teewinot Formation rests unconformably on the Bighorn Dolomite and the low rounded hill rising out of the flat south of this spur is the Madison Limestone overturned toward the southwest. The remainder of the downfaulted spur of the butte is the Teewinot Formation dipping west about 25 degrees. The high rounded summit with a few scattered trees in the distance to the north is vertical Madison Limestone with the Amsden and Tensleep extending into the prominent skyline notch to the left. This notch and the valley extending south from it mark the trace of the Flat Creek thrust or reverse fault, which splits Blacktail Butte in half. A post-Teewinot normal fault, coinciding with the trace of the Flat Creek fault, dropped the west half. It is almost, but not quite, all Teewinot Formation. The east half is of Paleozoic rocks except for the downfaulted southeast spur. A real anomaly is present, however, halfway up the southeast-facing slope west of this fault valley. The orange-pink sandstone outcrop marked by a few conifers directly ahead as we look at the butte is the Nugget Sandstone folded into a gentle northwest-trending, south-plunging anticline. It is overlain by very poorly exposed Gypsum Spring and fossiliferous Sundance Formations. The remainder of this face is Teewinot Formation. The relation of these Mesozoic strata to the Paleozoics east of the fault valley is not understood. The northwestern extent of the Flat Creek fault beyond Blacktail Butte is unknown because it is covered by outwash deposits. Several springs emerge along the fault and were the sites of campgrounds occupied by prehistoric Indians. Huge crude artifacts were quarried from quartzite zones in the Tensleep Sandstone and from glacial boulders, possibly from different sources.

In the foreground just above eye level to the northwest and north is a series of northeast-trending small Holocene normal faults, downstepped toward the southeast, offsetting loess and the underlying quartzite outwash gravel. They merge southward into a single fault that marks the eastern edge of the terrace-like feature that extends southward from Blacktail Butte, and which is capped by loess that overlies outwash gravel. The contact between these two lithologies is a very planar surface (**Figure 8**). It is not known at present whether all of this upper terrace-like feature is a horst or whether some (but not all) of the eastern margin is a terrace cut by the Gros Ventre River. The western margin of this surface has been described previously (Love and Love, 1983, milepoint 9.8), along with the incised channelways that cut it. Note that no such incised channelways are visible on the eastern margin.

Figure 8. View west at upper Miocene vertebrate fossil site near top of Teewinot Formation along the Kelly Road at Stop 10. The sequence consists of lacustrine soft marl, diatomite, tuff, pumicite, and sandstone. It is overlain unconformably by about 30 feet of Pleistocene outwash gravel and at the very top of the cut along the fence line is a thin mantle of loess. (Photograph by J.D. Love, October 6, 1951.)

If flood waters from the destruction of that impounded lake flushed westward across this surface between 4,000 and 5,000 years ago (as discussed in connection with the Devils Elbow Landslide, Stop 3), then the western fault scarp was already in existence and the eastern scarp was upfaulted later. What appears to be beheaded torrent channelways cross this surface in a southwesterly direction. Adding some credence to this interpretation is the report that the archeological sites on this surface are less than 5,000 years old.

2.2 6.0 **STOP 10.** Park on left side of road. This is the chief vertebrate fossil site in the Teewinot Formation, which dips 9 degrees southwest (**Figure 8**). This site has yielded aquatic mice, beavers, shrews, abundant mollusks, ostracodes, diatoms, and pollen, all of Late Miocene age (these fossils were originally considered to be of middle Pliocene age until the European Tertiary time scale was adopted). The strata are fine-grained, evenly bedded claystones, tuff, pumicite, and volcanic sandstone. About 100 yards to the northeast at river level are exposures of a lower section of claystones, pumicites, and tuffs in the Teewinot Formation. They are of interest because they can be correlated precisely, bed by bed, with a section exposed on the south side of the Gros Ventre River two miles to the south-southwest. This indicates very quiet-water deposition in this part of Teewinot Lake. At both sites an obsidian gravel bed is exposed and a K-Ar age of about nine million years was obtained from it in the southern section. This is near the top of 6,000 feet of the type Teewinot Formation.

Looking southeast across the river through a gap in the trees is a white scar visible at eye level. This is a bed of white pumice chunks, some as much as a foot in diameter. In several places where this bed is exposed it has been extensively pawed and licked by elk. Chemical analyses do not show any excessive amount of salt or any other unusual minerals essential to animals, but the elk seem to know something we don't know. Looking east through the trees toward the skyline is a good view of the Sleeping Indian (elevation 11,239 feet) near the west end of the Gros Ventre Range. Nose and chest are Madison Limestone, underlain by the Darby Formation and Bighorn Dolomite. The bare hills in the foreground in line with the Sleeping Indian are all part of the west-dipping Teewinot Formation, which is almost entirely soft white freshwater limestone, tuff, pumicite, and lacustrine shale and sandstone. No evidence of debris from the Teton Range was observed here or in exposures of the Teewinot Formation farther west, even those within two miles of the Teton front south of Moose. Therefore, it is assumed that the Teton mountain front as we see it today did not exist nine million years ago. About 3,000 feet of southward-moving pre-Wisconsin ice passed over and shaped the rounded hills of the Teewinot Formation to the east and south. This glaciation was much older than that which impounded the lakes along the west side of Jackson Hole. The fossiliferous strata in the Teewinot Formation at this stop are overlain unconformably by Pleistocene quartzite outwash gravel (**Figure 8**) and at the top of this, on a very even planar surface, is loess. Similar loess two miles to the south has yielded several ^{14}C ages ranging from 13,000 to 19,000 years.

2.2 8.2 Junction, Kelly Road and U.S. Highway 89/191/26. End of road log.

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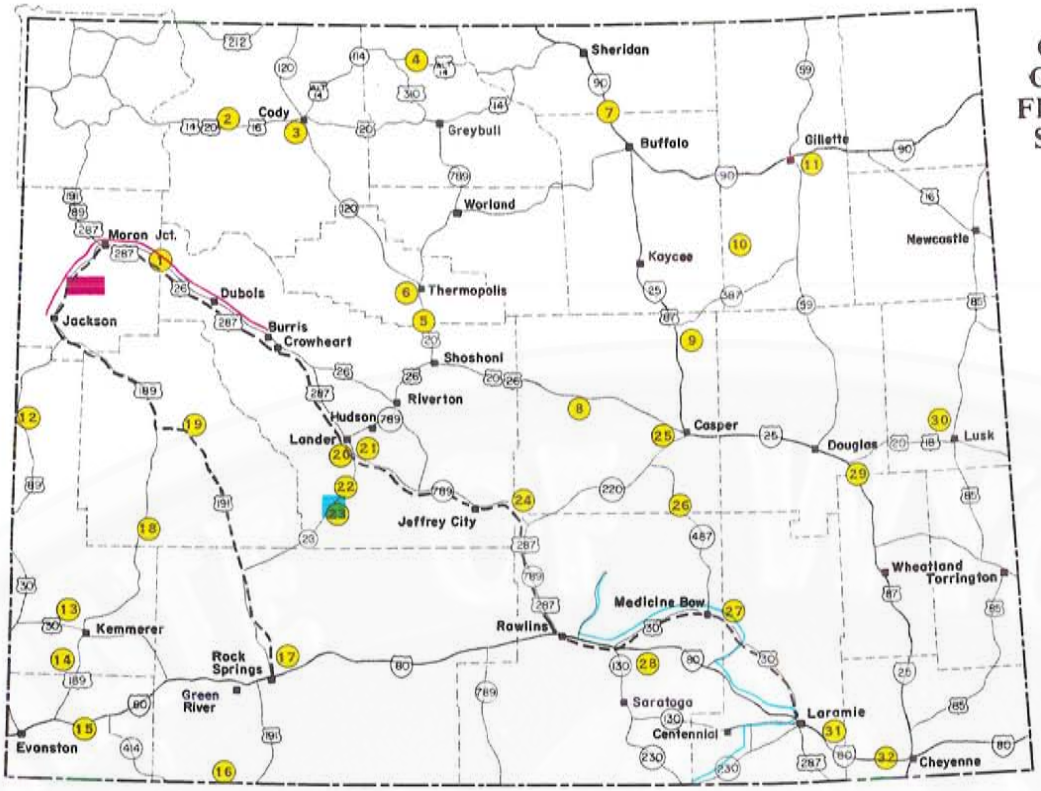

GUIDES TO WYOMING GEOLOGY AVAILABLE FROM THE GEOLOGICAL SURVEY OF WYOMING

Area of this road log

2

Stops in Bulletin 67 (Traveler's Guide to the Geology of Wyoming)

Route of PIC 20
(Jackson-Dinwoody road log)

Route of PIC 21
(Southeastern Wyoming road log)

Area of PIC 23
(South Pass gold mining district)

Route of PIC 27
(Laramie-Lander-Jackson-Rock Springs road log)

STATE OF WYOMING
GEOLOGICAL SURVEY
1933

Geology--Interpreting the past to provide for the future

Geologic Road Log of part of the Gros Ventre River valley [illegible]