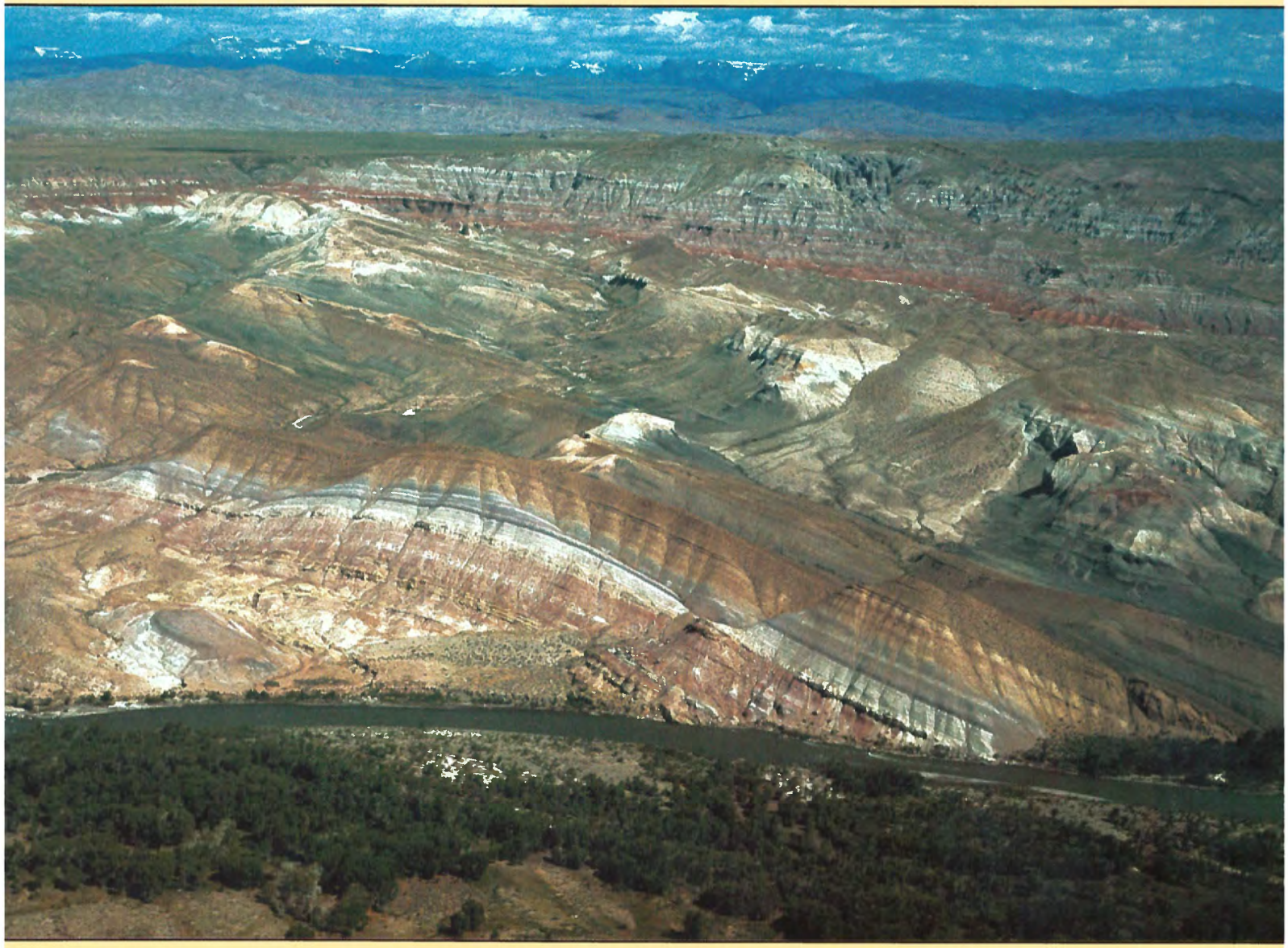
WYOMING STATE GEOLOGICAL SURVEY
Gary B. Glass, State Geologist

# GEOLOGIC ROAD LOG, JACKSON TO DINWOODY AND RETURN

by

J. David Love and Jane M. Love



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**Front cover:** Air oblique photograph looking north across the Wind River from a point about 14 miles southeast of Dubois. The steeply dipping strata in the lower middle part of the scene are Lower Cretaceous rocks on the northeast flank of the Wind River Range. The nearly horizontal candy-striped badlands in the upper middle part of the scene are the Wind River Formation, which unconformably overlies Cretaceous rocks and which thickens in the Wind River Basin to the southeast (right). The snow-covered mountains in the background are part of the Absaroka Range, composed of middle and upper Eocene volcaniclastic rocks. (Also see Figure 17, a photograph of the same units from a different angle.) Photograph by W.B. Hall, T.H. Walsh, and J.D. Love, July 7, 1974.

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Second Edition

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J. David Love and Jane M. Love

Prepared through the generous support of Dr. Daniel Canale, Bayard and Genie Copp, and Robert Boswell.

Laramie, Wyoming

1997

## Acknowledgments

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## Preface

This second edition is revised and reformatted from the second, corrected printing (1983) by the Wyoming State Geological Survey and the original version (1980) published in the Wyoming Geological Association's 31st Annual Field Conference Guidebook, p. 283-317. The first edition was reprinted with permission of the Wyoming Geological Association; we also acknowledge their permission for the second edition. This second edition contains numerous corrections and changes reflecting new data on ages of rocks and formations, changes in stratigraphic nomenclature, and new interpretations of some features based on further work. The original road logs have been modified to accommodate travel in the opposite direction; directions have been changed from reference with respect to the face of a clock to compass directions. Some photographs from the original guidebook article and the first edition of this publication could not be located, so their descriptions had to be modified to fit the alternate photographs used. We hope this publication will help in your enjoyment of this scenic area.

# Table of contents



# Illustrations

# Illustrations

# Introduction

This road log is presented in three segments. The first segment is logged from Jackson to Moran Junction. The second segment is logged from Moran Junction to the Dinwoody moraine, 18.7 miles southeast of Dubois. For travelers going in the opposite direction, mileages are also supplied from Dinwoody moraine to Jackson and from Moran Junction to Jackson. A different return route, the third segment, is logged between Moran and Moose; mileages are also supplied for travelers going in the opposite direction. All routes are shown on the relief map (**Figure 1**). All measurements are non-metric because nearly all the maps and odometers are non-metric. A full day is required to travel the entire route of the field trip and make all the recommended stops.

# Jackson to Moran Junction

| Mileage | | |
|---|---|---|
| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
| 0.0 | 0.0 | 32.2 |

Start at Flat Creek bridge on U.S. Highways 26/89/191 at north edge of Jackson. To the east is Jackson National Elk Refuge, drained by Flat Creek. In the winter, at least 5000 elk are fed on the meadows and swamps extending from the town of Jackson northeastward for about ten miles.

The geology of Grand Teton National Park and surrounding areas is shown on U.S. Geological Survey Map I-2031 (Love and others, 1992), scale 1:62,500 (color) and pamphlet, 17 pages. Additional geologic maps of the area include U.S. Geological Survey maps I-769-A (Love and Albee, 1972), OFR 78-480 (Love and Love, 1978), OFR 75-334 (Love, 1975), and OFR 75-335 (Love and Reed, 1975). An overview of the entire Jackson Hole-Teton region is shown on a block diagram (Love and others, 1973) and the geology of the Teton Range is given by Love and others (1992).

Miller Butte, on the valley floor a mile to the northeast, is composed of west-dipping Madison and Amsden Formations (Mississippian and Pennsylvanian) in a down-dropped fault block.

The timbered highlands east of Miller Butte are the western end of the Gros Ventre Range and are composed of west-dipping Madison, Amsden, and Tensleep Formations, as in Miller Butte. West of the highway is East Gros Ventre Butte, likewise composed of west-dipping Paleozoic rocks. This, and other buttes still farther west, out of sight, are fault-block remnants of the foundered ancestral Gros Ventre-Teton-Targhee uplift. This uplift foundered along north-trending faults that cut obliquely across the older, underlying Cache Creek thrust fault. This thrust is of Laramide age and involves a foreland block that moved southward and southwestward across Mesozoic rocks that stand vertically under the town of Jackson.

Snow King Mountain, with its conspicuous ski runs, on the south side of Jackson, is composed of Paleozoic rocks thrust northward along the leading edge of the Idaho-Wyoming thrust belt. This thrust fault, the Jackson thrust, is slightly older than, and was overridden in places by the Cache Creek thrust, which moved in the opposite direction (**Figure 2**). None of the mountains between Jackson Hole and Utah in the Thrust Belt has exposed roots of Precambrian rocks. At the base of Miller Butte is a series of large, slightly warm springs that do not freeze over in winter and thus provide a haven for year-round occupancy by the rare trumpeter swans.

The Paleozoic rocks at the south end of East Gros Ventre Butte are folded down because of drag along the Cache Creek thrust fault. They range from the Bighorn Dolomite (Ordovician) just above the town level, to the Phosphoria Formation (Permian) near the top of the butte west of the Maverik gas station. The top of the butte is capped by scoriaceous red and black basalt, probably of Tertiary age.

| | | |
|---|---|---|
| 0.1 | 0.1 | 32.1 |

Bottom of road cut to west, at the time it was fresh, exposed loess containing snails with a $^{14}C$ age of 15,300 ± 500 years (**Figure 3**; Love and Taylor, 1962, locality 7, p. 139). This locality is on a post-loess downfaulted block so the downfaulting occurred less than 15,000 years ago. For the next four miles, the highway follows the trace of this post-loess fault.

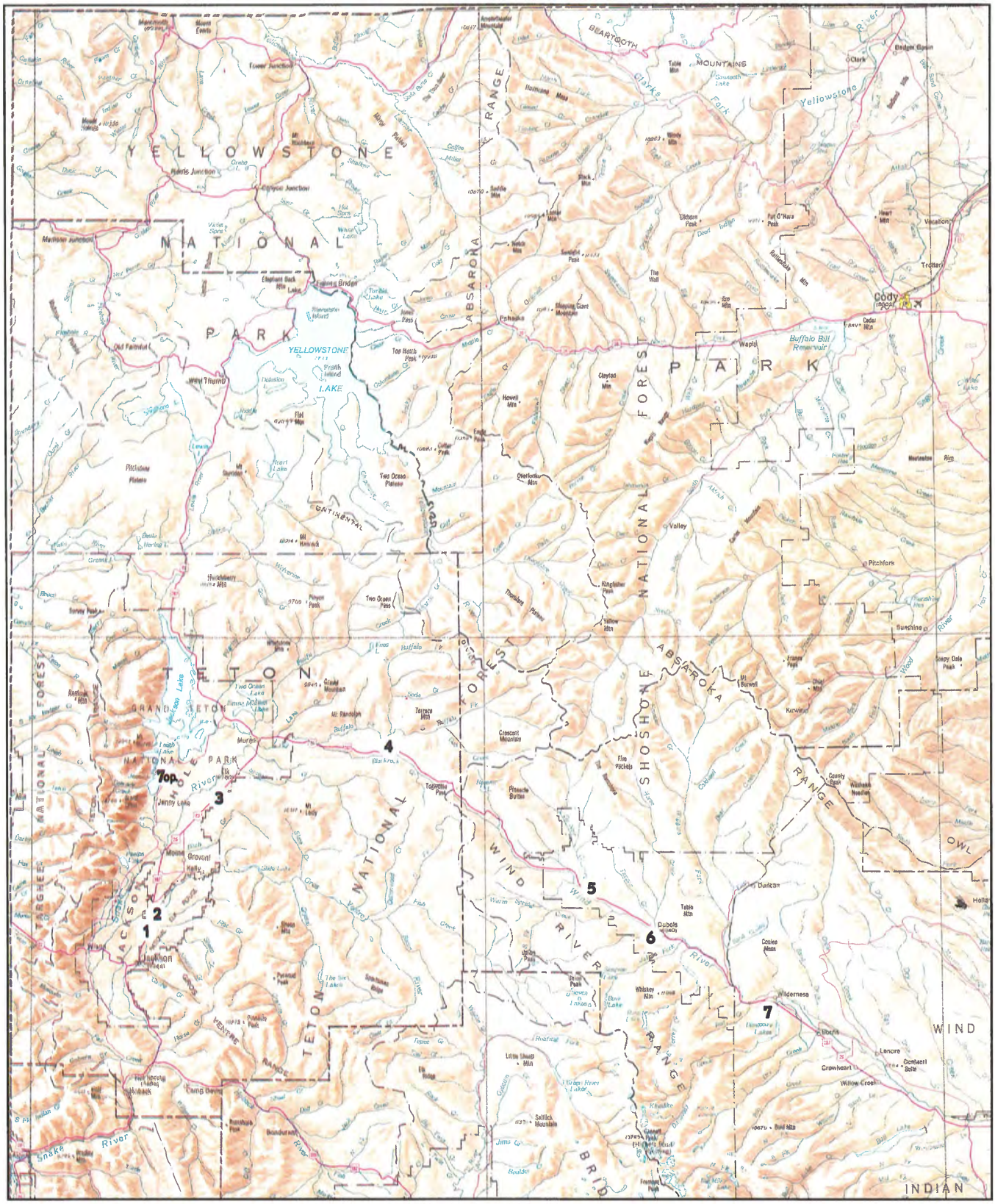



*Figure 1. Relief map of northwestern Wyoming showing major geographic features, field trip route, and suggested stops (numbered).*

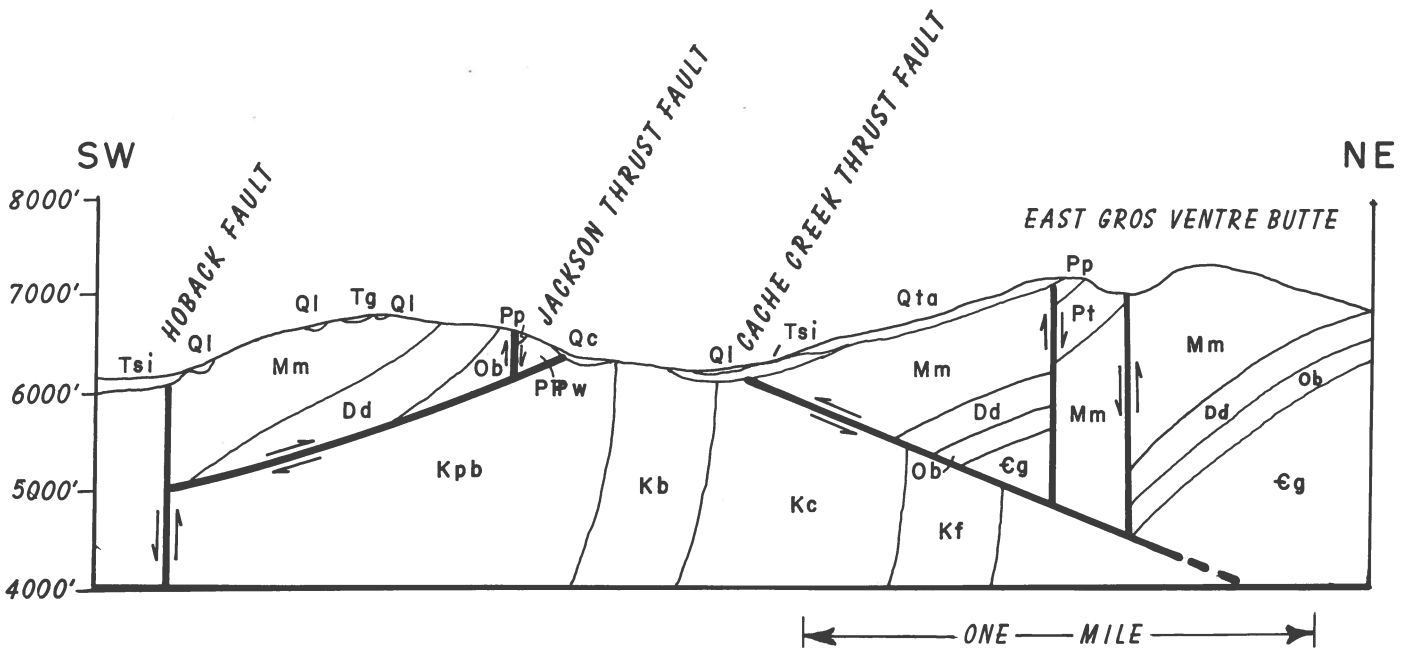



*Figure 2. Northeast-trending cross section a mile west of Jackson goes through East Gros Ventre Butte and shows the relation of the Jackson and Cache Creek thrusts (after Love and Albee, 1972). Symbols are: Qta - talus, Qc - colluvium, and Ql - loess, all of Quaternary age; Tg - basalt of Tertiary age; Tsi - Shooting Iron Formation (Pliocene); Kpb - post-Bacon Ridge strata, Kb - Bacon Ridge Sandstone, Kc - Cody Shale, and Kf - Frontier Formation, all of Cretaceous age; Pp - Phosphoria Formation (Permian); PPt - Tensleep Sandstone (Pennsylvanian); PPw - Wells Formation (Permian and Pennsylvanian); Mm - Madison Limestone (Mississippian); Dd - Darby Formation (Devonian); Ob - Bighorn Dolomite (Ordovician); and Cg - Gallatin Limestone (Cambrian).*

| Mileage | | |
|---|---|---|
| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
| 1.4 | 1.3 | 30.8 |

U-shaped saddle in butte to west was cut by pre-Wisconsin ice. Brown andesite on the north side of the saddle is of Late Tertiary age. This is one of eight distinct young volcanic sequences in the East and West Gros Ventre Buttes.

1.6 0.2 30.6

Road cut on west side of road at one time exposed snail-bearing loess from which a $^{14}C$ age of 13,980 ± 700 years was obtained (Love and Taylor, 1962, locality 6; **Figure 3**).

2.7 1.1 29.5

Ragged cliffs on butte to west are andesite, at base of which is a black obsidian glass phase. Beneath the glass are white tuffs of late Tertiary age which contain 26% $Al_2O_3$. These tuffs are incorporated in the landslide where the highway bends at mileage 3.1.

3.4 0.7 28.8

Turn northeast onto access road to Jackson Hole Fish Hatchery and proceed to parking lot of Hatchery.

4.0 0.6 28.2

Turnaround at Fish Hatchery parking lot. SUGGESTED STOP 1. This is an excellent place to contemplate the regional geologic and physiographic features and how they affect human activities. The "Sleeping Indian" (also known as Sheep Mountain) on skyline to the east is the highest peak in the western part of the Gros Ventre Range. Nearly flat-lying strata on the southwest side of the peak range in age from Cambrian to Mississippian [details of geology are on map of Blue Miner Lake Quadrangle (Love, unpublished)].

Directly east of the valley floor, the fluted terrain that looks like a series of uplifted lake terraces is actually caused by southward-moving pre-Wisconsin ice that scoured giant grooves along zones of weakness in west-dipping Paleozoic rocks. Ice there and at this stop was more than 2000 feet thick and extended up the bare slopes to the east, to the base of the conspicuous tree line. Conifers do not grow well on glacial debris of this particular age, which contrasts with younger morainal debris farther north in Jackson Hole where conifers are abundant. The lumpy white hills to the northeast are part of the type section of the Teewinot Formation of late Miocene age, about 10 to 6 million years old and 6000 feet thick.

The scarp traversed by the highway just north of the Fish Hatchery turnoff is a fault scarp, along which there has been about 150 feet of displacement in the

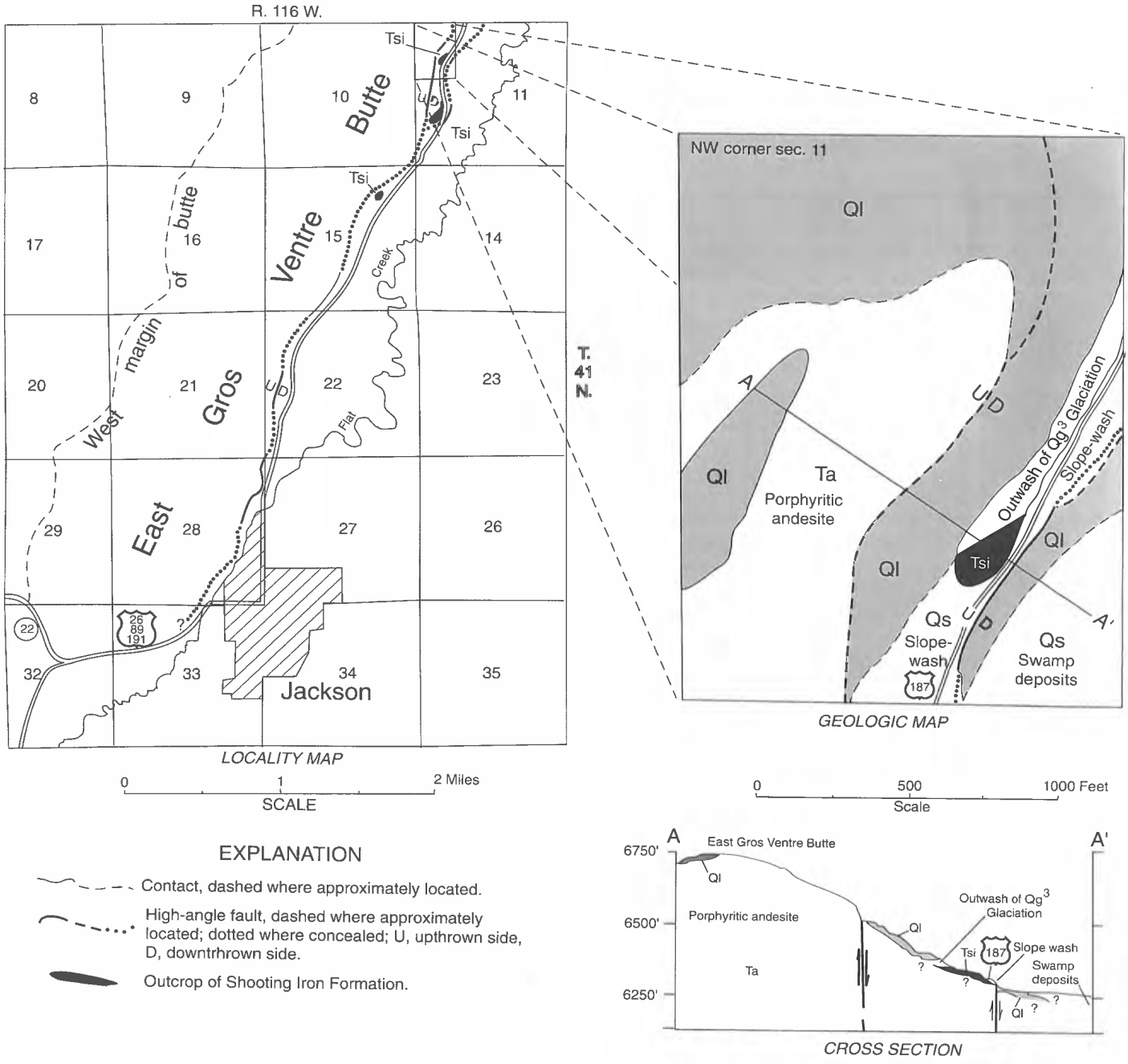



*Figure 3. Geologic sketch maps and cross section of Quaternary deposits along east margin of East Gros Ventre Butte. Deposits of Holocene age: slope wash and swamp deposits (Qs). Deposits of Pleistocene age: loess (Ql, stipple) and outwash of Bull Lake Glaciation ($Qg^3$). Deposits of Tertiary age: lacustrine sequence (Tsi, solid black), and porphyritic andesite (Ta). Modified from Love and Taylor (1962).*

last 12,000 years (see **Figure 3**). The valley block occupied by Flat Creek was dropped along this scarp and the loess-covered surface at the top of the scarp was tilted up to the east. The Cambrian Death Canyon Limestone Member of the Gros Ventre Formation, tilted gently to the north, is exposed in the scarp just north of the Hatchery.

**Mileage**

| Cumulative from Jackson | Increment | Cumulative from Dinwoody |
|---|---|---|
| 4.6 | 0.6 | 27.6 |

Return to main highway. Road cut to west, when it was fresh, is shown in **Figure 4**, and a detailed map and cross section through here is shown in **Figure 3**. Pliocene lacustrine deep-water mollusk-bearing shales

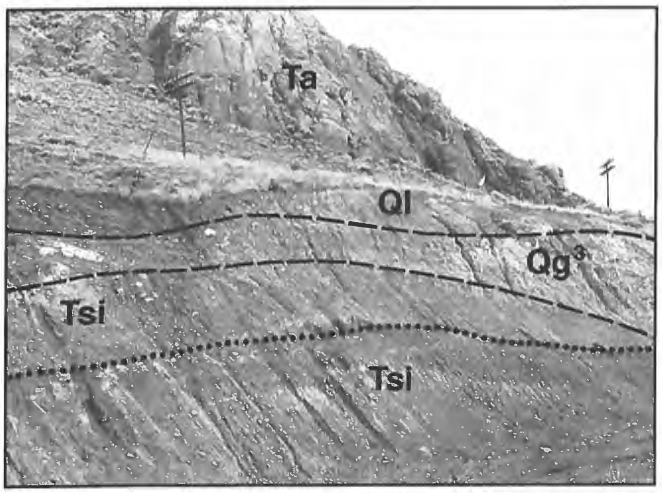



*Figure 4. Lacustrine sequence of the Shooting Iron Formation (Tsi), folded into gentle anticline delineated by main fossil zone (dotted line); porphyritic andesite (Ta); post-Bull Lake loess (Ql); and outwash of Bull Lake Glaciation ($Qg^3$). Modified from Love and Taylor (1962).*

of the Shooting Iron Formation are folded into a gentle anticline, downfaulted against the andesite cliff to the west (**Figure 4**). The mollusks, chiefly *Carinifex*, are presently known to exist at water depths between 120 and 300 feet (Love and Taylor, 1962). The exposures of till ($Qg^3$) just south of the lone pine tree are tilted 17° eastward as a result of drag along the fault that bounds the east edge of the butte.

| Mileage | | |
|---|---|---|
| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
| 4.9 | 0.3 | 27.3 |

In road cut on the west side of road, quartzite boulder gravels are cut off abruptly by a small fault which trends north along highway.

| | | |
|---|---|---|
| 5.1 | 0.2 | 27.1 |

Side road goes west up hill. In road cut just west of this junction the loess contains snail shells with a $^{14}C$ age of 19,000 years (Meyer Rubin, written communication, 1965, Sample W-1560; Love and others, 1965, p. 40). On east side of highway is sharp contact between grass-covered loess above and sage-covered quartzite outwash gravel below. This sequence is downfaulted to the valley floor at the Fish Hatchery.

| | | |
|---|---|---|
| 5.8 | 0.7 | 26.4 |

Park boundary turnout. SUGGESTED STOP 2. Looking north (12 o'clock), the landscape is dominated by the Teton Mountain front rising abruptly from the flat valley floor with no intervening foothills. The break in slope marks the position of the Teton normal fault on which the total displacement is estimated to be about 35,000 feet. The highest peaks are composed of the Mount Owen Quartz Monzonite whose age is 2547 ± 3 million years (Zartman and Reed, 1998, in press). The deepest canyon at 11 o'clock is Death Canyon, cut in Precambrian layered gneiss and migmatite, the oldest rocks in the range. Their age is greater than 2700 million years. South of Death Canyon, layered Paleozoic rocks are visible and increase in thickness southward as the Precambrian rocks decrease in outcrop extent. At 9 o'clock is the Teton Village tram which goes to the top of Rendezvous Mountain. The upper end of the tram is on the Devonian Darby Formation. The base of the Cambrian rocks is at the marked change of vegetation a little more than halfway up the mountainside. About three miles to the left of the tram, Paleozoic rocks bend down sharply to the south and are faulted along the Rendezvous Peak fault (for the geology of this area, see Schroeder, 1972; for the geology of the Teton Range, see Love and others, 1992). For the following discussion, refer to **Figure 5**.

On the valley floor to the west is the north end of West Gros Ventre Butte which is composed in part of Paleozoic rocks overlain and cut by andesite, probably the same as that in the foreground at the north end of East Gros Ventre Butte. The geology of the valley floor area all around this stop is shown in detail by Love (1975) and Love and others (1992).

The Warm Spring fault, underlying this stop, is a major east-northeast-trending nearly vertical fault which lines up with the Rendezvous Peak fault but probably is not related to it. The Rendezvous Peak fault is downthrown on the south, whereas the Warm Spring fault is downthrown 6000 feet or more on the north. Cambrian and Ordovician strata on the south are faulted against the upper part of the 6000-foot-thick Teewinot Formation, so this movement occurred less than 6 million years ago. There is no surface expression of the Warm Spring fault, but Warm Spring (behind us at 8 o'clock) emerges along this fault. It extends east-northeast across the Flat Creek valley and continues southeastward up Flat Creek Canyon on the southwest side of the Sleeping Indian (unpublished geologic mapping of Blue Miner Lake Quadrangle by J. D. Love).


*Figure 5. Air oblique photograph (view is to west) showing geology in vicinity of Stops 1 and 2. Indicated are A - Stop 1; B - Stop 2; C - andesite on north end of East Gros Ventre Butte; D - road cut in big landslide, exposing Pliocene lacustrine sequence; E - site of lacustrine sequence shown in Figure 4; F - two outcrops of Bighorn Dolomite; G - two outcrops of Death Canyon Limestone Member of Gros Ventre Formation; H - outcrops of upper part of Teewinot Formation; I - Warm Spring (temperature 80° F); J - north end of West Gros Ventre Butte, composed of Paleozoic rocks capped by andesite; K - scarp of fault less than 15,000 years old; L - Flat Creek near where it was deflected by rise of west fault block and downdropping of valley (east) block; M - beheaded channelways of Flat Creek before faulting, incised in loess about 15,000 years old; N - Gros Ventre River; and O - Flat Creek alluvial fan where it grades into swamp. Bar and ball on downthrown side of Warm Spring fault with at least 6000 feet of displacement. Photograph by J.D. Love, July, 1965.*

Straight ahead to the north, the line of trees at eye level marks the Gros Ventre River which is a major stream on an upland plain, in contrast to Flat Creek, which is a minor stream in a broad deep valley 100 feet or more lower than the Gros Ventre River. Flat Creek originally flowed westward into the Gros Ventre River across the upland plain visible to the north of this stop. This plain was tilted up to the east and down to the west (you can see how much by projecting the surface eastward toward the Gros Ventre Range) at the same time the valley of Flat Creek was downfaulted. This episode of tectonism, less than 12,000 years ago, diverted Flat Creek southward through Jackson. Beheaded channelways of ancestral Flat Creek can be seen going at right angles to the highway north of this stop.

| Mileage | | |
|---|---|---|
| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
| 7.3 | 1.5 | 24.9 |

Bridge across Gros Ventre River.

| | | |
|---|---|---|
| 7.8 | 0.5 | 24.4 |

Gros Ventre Junction. Paved road to east goes to Kelly; road to west goes to golf course.

| | | |
|---|---|---|
| 8.4 | 0.6 | 23.8 |

For next two miles on east side of road is a prominent

scarp which may be a post-loess (post-12,000 years) fault scarp rather than a stream terrace. At top is a vegetation change between grass-covered loess above and sage-covered quartzite gravel below. Several post-loess normal faults cut obliquely across this upland surface. This scarp merges northward with the fault scarp along the west side of Blacktail Butte.

| Mileage | | |
|---|---|---|
| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
| 9.8 | 1.4 | 22.4 |

Turnoff to west goes to Jackson Hole Airport. On top of upland surface to east are several archeological sites, all less than 5000 years old. Note that drainages coming off the upland surface are incised to level of the surface traversed by the highway. In contrast, on the east side of this upland surface, channelways are beheaded, not incised. This suggests that flood waters caused by breaking of a landslide dam on the Gros Ventre River 5000 years ago may have crossed this upland surface as it was rising along faults bounding its east and west margins.

10.8 1.0 21.4

Blacktail Butte to northeast is a complex fault block that has been scoured, faceted, and overridden by southward-moving pre-Wisconsin ice. The highest part (west half) of the butte consists of west-dipping white limestone and tuff in the Teewinot Formation. The east half of the butte is not visible from here, but it and the north end are 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 cannot be a downfaulted remnant of the east flank of the ancestral Teton Range but is instead, part of a separate uplift. The east and west halves are separated by a north-trending post-Teewinot normal fault. The detailed geology is shown by Love (1975) and on the Moose Quadrangle (unpublished mapping by J.D. Love).

11.1 0.3 21.1

As seen to the west-northwest, Death Canyon cuts through the east face of the Teton Range. The rocks exposed on both walls of the canyon are layered gneiss and migmatite, the oldest rocks in the Teton Range, more than 2700 million years old. The break in slope at the base of the mountain front marks the approximate trace of the Teton normal fault.

11.7 0.6 20.5

Directly east on the lower slopes of Blacktail Butte, is a sharp even line marked by vegetation changes. This line extends for about half a mile and is the contact between two glacial deposits of unknown age and origin. They are much older than the pre-Wisconsin ice that overrode Blacktail Butte. The faceted spurs composed of these glacial deposits are thought to be fault facets. The white Teewinot Formation is on spurs north of the last trace of the till line.

13.5 1.8 18.7

Moose Junction; to west is turnoff to Grand Teton National Park Headquarters at Moose. Continue north (if headed to Moran) or south (if headed to Jackson) along the main highway.

13.8 0.3 18.4

Cliffs to east are Madison Limestone standing nearly vertically, extending north to north end of butte.

14.4 0.6 17.8

"Climber's rock," a vertical wall of Madison Limestone used as a practice face for novice rock climbers.

14.6 0.2 17.6

Cross Ditch Creek. Road to east goes to Antelope Flats.

14.8 0.2 17.4

To the southeast, Lower Gros Ventre landslide is visible eight miles away, cutting through dense stand of trees on south side of Gros Ventre River. This slide occurred in 1925 and is the largest historic landslide in the United States, with a volume between 20 and 50 million cubic yards of debris. It created a dam about 225 feet high, behind which a lake more than four miles long was impounded. In 1927 the top 50 feet of the dam washed out and the resulting flood destroyed the town of Kelly, many of the ranches and highway bridges downstream, and drowned several people. A detailed account of the slide and references to previous studies was written by Voight (1978). A discussion of the slide's relation to earthquakes was given by Smith and others (1977, p. 603-610).

17.0 2.2 15.2

Glacier View turnout on west side of road. **Figure 6** is a closer view of the higher peaks and adjacent can-

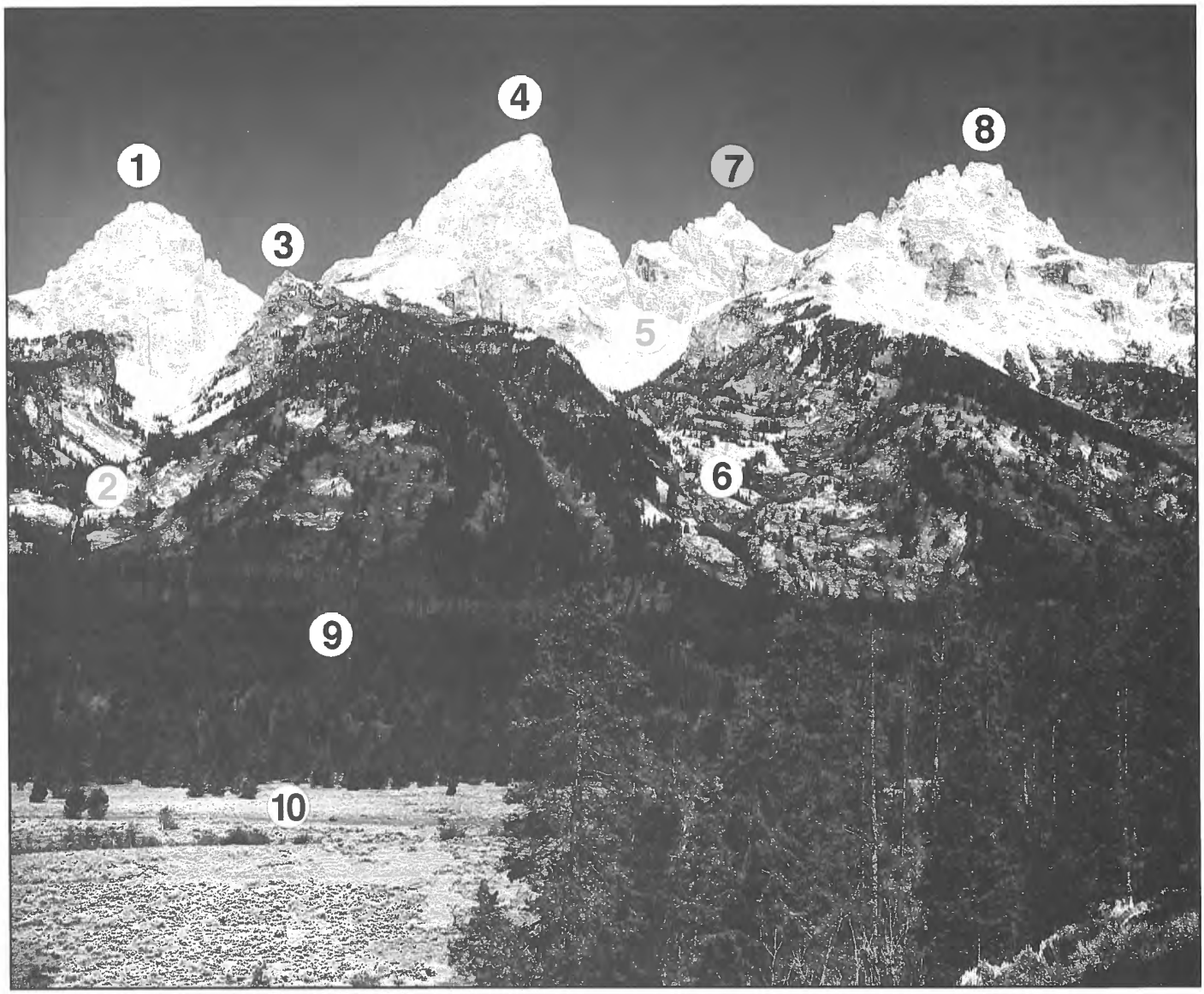



*Figure 6. Cathedral Group of Teton peaks. View west from Timbered Island. The most important geologic and topographic features are numbered as follows: 1 - Middle Teton; 2 - Garnet Canyon; 3 - Disappointment Peak; 4 - Grand Teton; 5 - Teton Glacier; 6 - Glacier Gulch; 7 - Mount Owen; 8 - Mount Teewinot; 9 - Pinedale glacial moraine; and 10 - outwash plain along highway. Details of the mountain front are shown in Figures 27, 28, and 29. Photograph by J.D. Love, June, 1955.*

yons. There will be an opportunity to photograph the mountain front from the next stop. Our route from Jackson has climbed up from the Snake River terraces to a vast outwash plain formed by meltwater from Wisconsin-age ice that crossed the valley floor at the next stop. (See Good and Pierce, 1996, for a description of this surface.) Note the westward tilt of this surface. Inasmuch as the outwash buries loess that is thought to be about 15,000 years old, this westward tilting was developed since that time. To the south, the wedge shape of Blacktail Butte is clearly seen. The east face of the butte, which we have not seen before, is a fault face cut across Paleozoic rocks that have been overturned westward.

**Mileage**

| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
|---|---|---|
| 22.3 | 5.3 | 9.9 |

SUGGESTED STOP 3. Snake River Overlook. Walk to area of Park Service sign. This is south margin of the Burned Ridge moraine, marked by trees, that extends across the floor of Jackson Hole, but which has been breached by the Snake River in the foreground. Note that trees are common on morainal debris but sparse or absent from the outwash debris. They are very selective as to where they will or will not grow. For identification of features in the panorama to the west, refer to **Figure 7**. The outwash plain that the route from Jackson has traversed for the last five miles

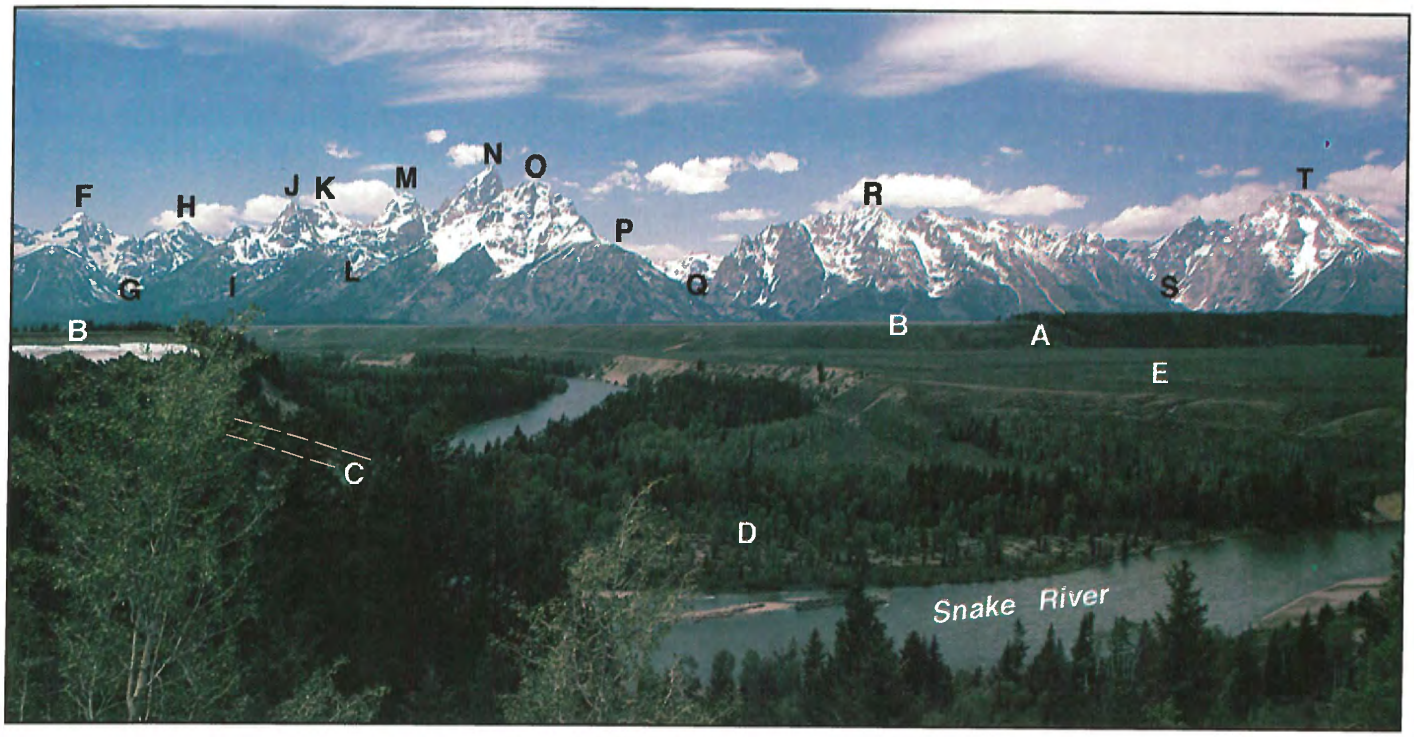



*Figure 7. View southwest across Snake River from Stop 3 at Snake River Overlook. Indicated are: A - Burned Ridge moraine; B - Burned Ridge outwash plain; C - Huckleberry Ridge Tuff; D - Deadman's Bar; E - outwash plain from Jackson Lake glaciation; F - Buck Mountain; G - Avalanche Canyon; H - Mount Wister; I - Garnet Canyon; J - Nez Perce (Howling Wolf); K - South Teton; L - Glacier Gulch; M - Middle Teton; N - Grand Teton; O - Mt. Teewinot; P - approximate upper limit of pre-Wisconsin ice; Q - Cascade Canyon; R - Mount St. John; S - Leigh Canyon; and T - Mount Moran, with vertical black dike cutting through it. Dashed line indicates approximate position of Huckleberry Ridge Tuff. This mountain front is shown in more detail in Figures 25-28. Photograph by R.W. Jones, June, 1979.*

route from Jackson has traversed for the last five miles was deposited by meltwater from the Burned Ridge ice which built up the moraine and occupied the cavity to the north and northwest.

The meltwater channelways, which can best be seen from the air, trend southward, yet today there is a westward component to the tilt of this surface. For example, this surface rises to 7040 feet directly east of us. We are at 6905 feet here, and the surface lowers to 6800 feet four miles directly west of us. Similarly, a traverse four miles south, again at right angles to the meltwater channelways, shows that the west margin of the surface is 50 feet lower than the east margin. Thus, the westward component of tilt ranges from 50 to 260 feet in less than 15,000 years, or between one foot in 300 years and one foot in 58 years. For other profiles showing westward tilting, see Love and Montagne (1956, p. 169-178).

After this outwash surface was developed, and probably within the last 10,000 years, the Snake River cut the channel seen in the foreground, 285 feet deep, through the Burned Ridge moraine and the adjacent outwash gravel. The river is no longer able to cut down so it must have been much larger for a considerable interval of time during the last 10,000 years. This will be discussed further in connection with the return trip to Jackson on the west side of the Snake River.

The gravel bar on the west side of the river is known as Dead Man's Bar because it was the site of a pioneer placer gold venture that ended in tragedy. Four Germans spent the summer of 1886 placering the gold from quartzite gravels. Then one man killed the other three and reportedly cooked parts of them in a big cast iron pot that is now in the Jackson museum. He left the country but was brought back, tried for murder, and acquitted when he pleaded self-defense.

From a view site 25 feet south of the Park Service panorama sign, it is possible to see ragged brown ledges projecting out into the river (see **Figure 7**). These ledges are the farthest south remnant of the Huckleberry Ridge Tuff, 1.9 million years old, that flowed south from a giant caldera in Yellowstone Park. These

rhyolitic welded tuffs would have been deposited with a horizontal east-west strike, but are now tilted west 13° as a result of downhinging of the floor of Jackson Hole after the tuffs were emplaced. If the movement were averaged out it would be about one foot every 1600 years at this site.

The inner terraces along the Snake River represent stages of downcutting through Quaternary quartzite gold-bearing gravel. Looking northwest from the north parapet, one can see a broad treeless plain with tufts of conifers that mark glacial kettles (locally known as "potholes"). The treeless land surface indented by the kettles is an outwash plain deposited by meltwater from the Jackson Lake moraine, which is marked by the elevated line of trees at the far edge of the plain. The Jackson Lake moraine is the youngest on the floor of Jackson Hole. Here again, conifers grow abundantly on moraines from the granitic rocks of the Tetons, but prefer not to grow on the quartzite outwash debris.

To the north, six miles away, the prominent wedge-shaped uplift is Signal Mountain, an ice-carved butte of resistant rocks. The prominent ledge on the bare east-facing slope is the Huckleberry Ridge Tuff, dipping westward about 7° as a result of westward tilting of the floor of Jackson Hole after emplacement of the tuff 1.9 million years ago.

The highest peak, to the right of Signal Mountain on the skyline, is Whetstone Mountain composed of conglomerate, sandstone, and marine or brackish water shales in the Harebell Formation of latest Cretaceous age. The most elaborate gold placer mining project in Jackson Hole up to the present time was launched on the east side of Whetstone Mountain in 1889. The gold came from quatzite conglomerate in the Harebell Formation. We will see similar conglomerates close up on the way to Togwotee Pass.

Looking east from the highway level parking area, the white outcrops on the densely wooded hillside are west-dipping tuffs in the Teewinot Formation of late Miocene age. In the foreground to the east, the lumpy hills are remnants of the Burned Ridge moraine partly buried by quartzite outwash gravel.

Mileage

| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
|---|---|---|
| 24.2 | 1.9 | 8.0 |

Ridges here are all along the edge of the moraine-outwash interface that we saw at Stop 3.

| | | |
|---|---|---|
| 24.9 | 0.7 | 7.3 |

On the south side of the road, white beds of ash and marl represent a lake impounded behind the Burned Ridge moraine after the main mass of Burned Ridge ice had largely melted (see Good and Pierce, 1996).

| | | |
|---|---|---|
| 25.7 | 0.8 | 6.5 |

Road to right goes to Triangle X Dude Ranch.

| | | |
|---|---|---|
| 26.5 | 0.8 | 5.7 |

Turn north to lay-by at entrance of road to Cunningham Cabin but do not take road to the cabin. Look to the northeast. This is the best place, that is free of traffic hazards, to see a straight-line, east-trending, only slightly modified post-glacial fault scarp three miles long and as much as 300 feet high. It cuts without deflection across sandstone and gold-bearing quartzite boulder conglomerates, coal, and marine shale in the Bacon Ridge Sandstone (Upper Cretaceous), several till sequences, and interglacial deposits (**Figure 8**). The south block is dropped and the north block uptilted. Note a series of hanging valleys along the fault scarp, indicating at least two episodes of upfaulting of this block.

Signal Mountain is directly to the north. The previously mentioned ledge of Huckleberry Ridge Tuff is plainly visible. In line with Signal Mountain, but south of it, the trees mark the southern limit of Jackson Lake morainal debris on far side of treeless outwash plain.

| | | |
|---|---|---|
| 27.3 | 0.8 | 4.9 |

Those traveling north can get brief glimpses of the Spread Creek fault through the trees.

| | | |
|---|---|---|
| 28.2 | 0.9 | 4.0 |

Cross Spread Creek. Beginning about 700 feet east of the bridge and extending eastward for $\frac{3}{4}$ mile, the fault scarp exposes gold-bearing quartzite conglomerates and coal beds intertonguing with marine and brackish water sandstones and shales of the Bacon Ridge Sandstone. The geology of this area is shown on the Moran Quadrangle (Love, unpublished geologic map). Some quartzite boulders are as much as 18 inches in diameter. They are not locally derived but came from the ancestral Targhee uplift to the west. These boulders are the first evidence that the uplift was deroofed to its Precambrian core as far back as middle Niobrara time (83 million years ago). Powerful rivers flowed

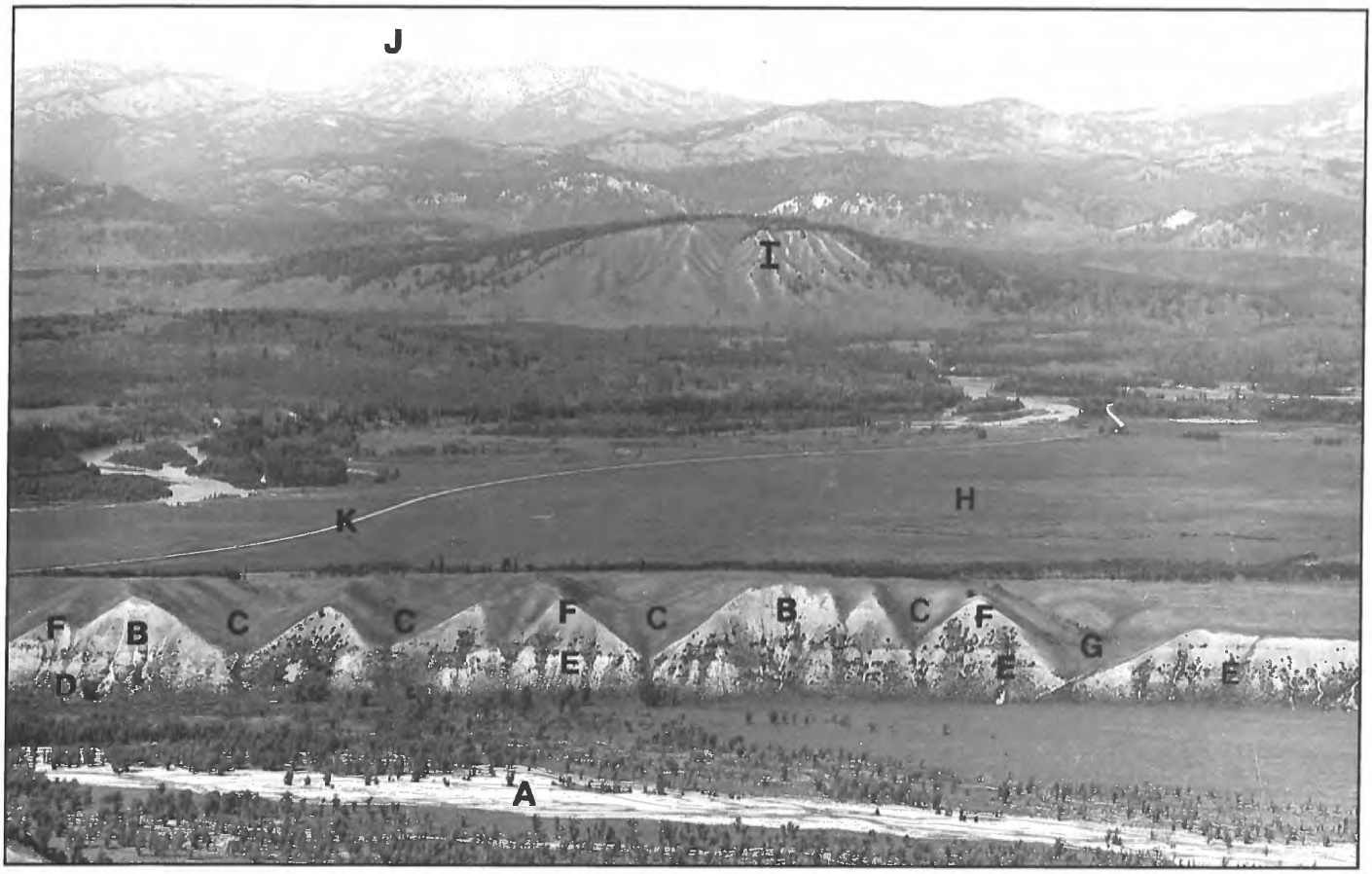



*Figure 8. View north at Spread Creek fault scarp. Indicated are: A - Spread Creek on gravel fan; B - Spread Creek fault scarp; C - hanging valleys that indicate two stages of faulting; D - Bacon Ridge Sandstone containing gold-bearing quartzite conglomerate, coal, and marine strata; E - Pleistocene lacustrine and fluviatile beds; F - till of Burned Ridge glaciation; G - post-glacial cross fault; H - clay and silt alluvial fan of Spread Creek; I - Lozier Hill, composed of 1000 feet of Pinyon Conglomerate; J - Wildcat Peak, composed of Bacon Ridge Sandstone; and K - U.S. Highway 26/89/191 along field trip route. Photograph by J.D. Love, June, 1967.*

eastward into the Cretaceous sea in this area 70 ± million years before the modern Teton Range rose. The configuration of the Targhee uplift was similar to that shown at a later stage in the Cretaceous (Love, 1973, figure 15).

Northbound travelers should note that after crossing the Spread Creek bridge, the highway goes northeast, downhill 100 feet in the next 3.5 miles, yet the adjacent Snake River is flowing southwest in the opposite direction. Spread Creek, itself, flows north into the Snake River. This peculiar behavior of the streams and configuration of the land surface is the result of sagging of the area east of Signal Mountain (see discussion in return trip road log). As a result of uplift of the fault block north of Spread Creek and crustal sagging still farther north, Spread Creek splits three miles east of the bridge into a number of stream systems (hence the name), and each has built an alluvial fan. The gravel fan is west of the highway and the silt and clay fan is north and to the east on the big flat that the highway traverses for three miles.

| Mileage | | |
|---|---|---|
| Cumulative from Jackson | Increment | Cumulative from Moran Jct. |
| 31.2 | 3.0 | 1.0 |

To the northeast is Whetstone Mountain, composed chiefly of gold-bearing quartzite conglomerate in the Harebell Formation of Late Cretaceous age.

| | | |
|---|---|---|
| 32.0 | 0.8 | 0.2 |

Cross bridge over Buffalo Fork River (a fork of the Snake River) about 100 yards upstream from its junction with the Snake River.

| | | |
|---|---|---|
| 32.2 | 0.2 | 0.0 |

Moran Junction and end of first road log. U.S. Highway 89/287 goes west into Grand Teton National

Park and U.S. Highway 26/287 goes east to Dubois (**Figure 9**). For those not going to Dinwoody and wishing to tour the geology to the west, use return trip road log, Jackson to Moose, pages 30 to 35.

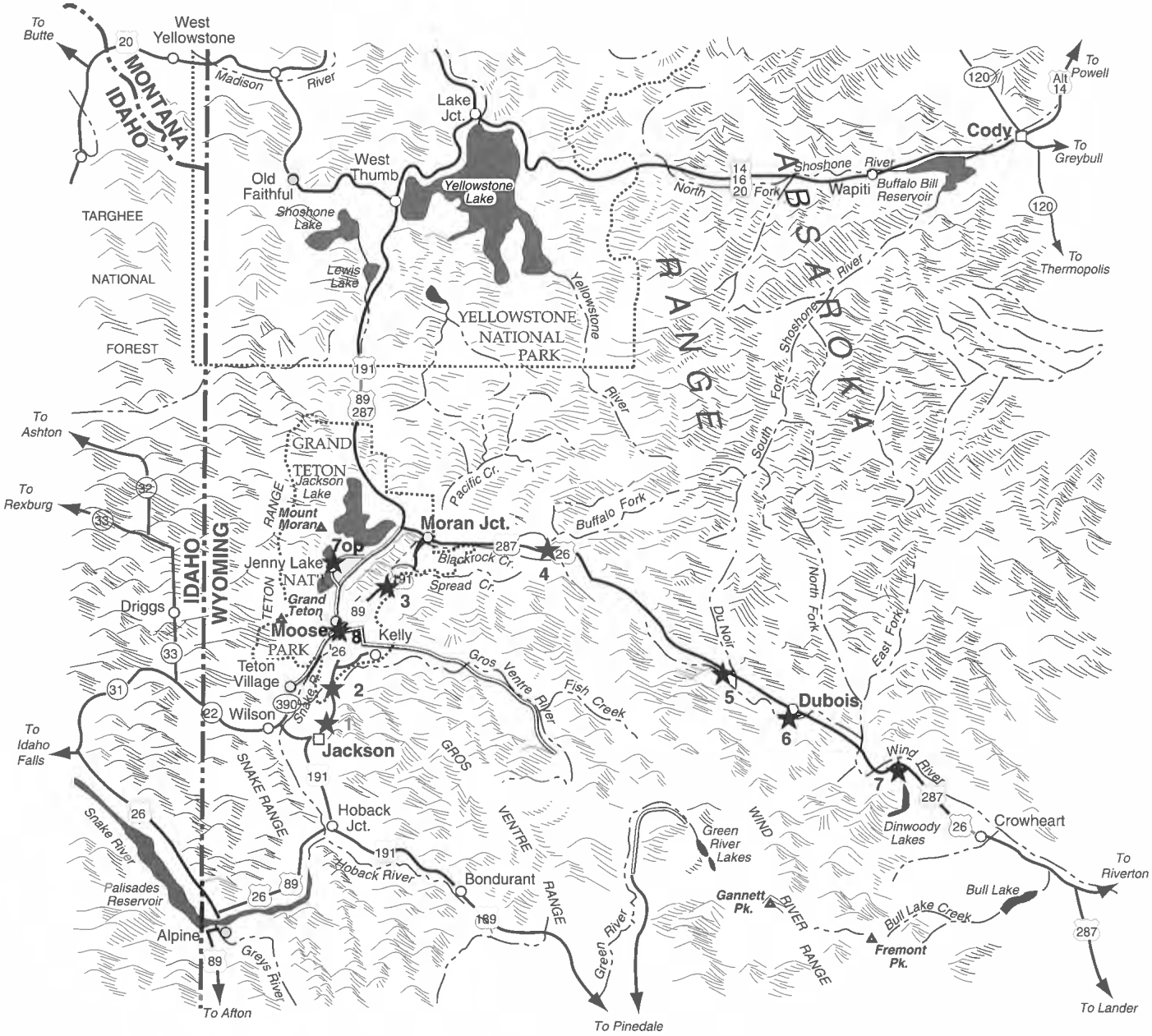



*Figure 9. Index map of northwestern Wyoming and surrounding area showing field trip routes, suggested stops, and other major highways.*

# Moran Junction to Dinwoody

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 0.0 | 0.0 | 76.4 |

Moran Junction. Reset both interval and cumulative mileages to zero. Continue east on Highway 26/287.

0.6 0.6 75.8

Steeply dipping, hard, thin, gray sandstones, shales, and coal beds are part of the Sohare Formation on the west flank of the Spread Creek anticline. The geology for the next six miles to the east is shown on the Davis Hill Quadrangle map (Love, unpublished).

2.1 1.5 74.3

East boundary of Grand Teton National Park.

2.8 0.7 73.6

Cross Lava Creek bridge. Cliffs visible up Lava Creek to the north are Bacon Ridge Sandstone at crest of Spread Creek anticline. A coal bed in the sandstone here was mined by the Bureau of Reclamation between 1910 and 1916. This is the largest anticline with Upper Cretaceous rocks in its core in Jackson Hole; it is about 20 miles long, has 6000 feet of closure in some places, is of pre-Tertiary age, and has several large flammable gas seeps along its crest. It has been tested unsuccessfully for oil and gas in several places during the last 52 years.

3.1 0.3 73.3

On left are old tipples and dumps of abandoned coal mines. The coal is in the Bacon Ridge Sandstone. Some of the coal was used for power in building the Jackson Lake Dam between 1910 and 1916. The True-Travis oil test is about 500 feet north of the highway near the western tipple. This test, drilled in 1958 to a depth of 4367 feet, spudded in the Bacon Ridge Sandstone, and reported the following tops: Cody Shale, 380 feet; Frontier Formation, 2495; Mowry Shale, 3310; Muddy Sandstone Member of Thermopolis Shale, 3989; Cloverly Formation, 4205; Morrison Formation, 4310 feet.

3.7 0.6 72.7

Bridge across Buffalo Fork River.

4.5 0.8 71.9

Directly to the south on the skyline is Mount Leidy, the triangular peak with fluted sides. It is composed of the Pinyon Conglomerate, a gold-bearing quartzite conglomerate which here is entirely of Paleocene age. It rests in places with a 90° unconformity on vertical Cretaceous rocks along the west flank of the Spread Creek anticline. At the south edge of the floodplain traversed by the highway, where the subdued glaciated hills of Cretaceous rocks rise above the plain, are several large seeps of flammable gas that issue from the Bacon Ridge Sandstone on the crest of the Spread Creek anticline. **Figure 10** shows the largest one which blows a flare when ignited. In pioneer days, this was a favorite place for cattle roundup wagons to camp because the cook did not have to chop wood but merely put a vented metal barrel over the seep, lit it, and cooked the meals on the barrel.

6.6 2.1 69.8

Burro Hill is on the north side of Buffalo Fork River. The drab sandstones and shales are near the base of a

*Figure 10. Flare from ignited gas seep emerging from Bacon Ridge Sandstone on Spread Creek anticline south of Halfmoon Lake. Photograph by Roger Matson, November, 1977.*

5000-foot-thick section of the Harebell Formation of Late Cretaceous age. This is the basal part of the Rosies Ridge measured section (Love, 1973, section 11, figure 7, p. A10). The hills south of highway are likewise made up of the Harebell Formation, which extends for 10 miles eastward along the highway.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 8.3 | 1.7 | 68.1 |

Hatchet Motel to south.

| | | |
|---|---|---|
| 8.7 | 0.4 | 67.7 |

Bridge across Blackrock Creek. The geology for the next six miles is shown on the Rosies Ridge Quadrangle map (Love, unpublished).

| | | |
|---|---|---|
| 8.9 | 0.2 | 67.5 |

Ledges on left are part of the sandy facies of the Harebell Formation (approximate equivalent of the Lance Formation of central and eastern Wyoming). For the next five miles to the east, the road cuts (and the landslides) are all in the Harebell Formation. Because the highway cut into potentially unstable strata of the Harebell on steep slopes, much of the highway for the next few miles is prone to sliding each year.

| | | |
|---|---|---|
| 11.0 | 2.1 | 65.4 |

Quarry on north side of highway at bend is the site of the best *Chara* (fossil algae) collections in this section of the Harebell Formation. The *Chara* are in a dark gray claystone interbedded with quartzite conglomerate and are associated with mollusks and pollen.

| | | |
|---|---|---|
| 11.7 | 0.7 | 64.7 |

Gold-bearing quartzite conglomerates (**Figure 11**) in the Harebell Formation are in road cuts for the next two miles. The quartzite clasts were not locally derived from any of the adjacent mountains, but were brought in at least 50 miles by powerful rivers drain-

*Figure 11. Closeup of conglomerate and sandstone in Bobcat Member of Harebell Formation in fresh road cut on north side of U.S. Highway 287. Note fracturing of quartzite clasts. Sandstone matrix contains very small flakes of gold. Photograph by J.D. Love, September 6, 1966.*

ing eastward from the now-subsided Targhee uplift in Idaho (for configuration of the uplift at this time, see Love, 1973, figure 15, p. A28).

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 13.2 | 1.5 | 63.2 |

Road cut on south side of highway is site of a dinosaur quarry (**Figure 12**). This quarry yielded, in addition to ceratopsian dinosaur fragments, remains of salamanders, fish, alligators, mollusks, *Chara*, and pollen (Love, 1973, p. A27).

16.4 3.2 60.0

Cross Quaternary fault scarp which trends north across highway. It offsets glacial debris. The east block is dropped at least 50 feet and has ponded drainage. The trace of the fault can be followed north and south on air photos for about two miles through dense timber. From here on to the east for the next six miles, the geology is shown on the geologic map of the Angle Mountain Quadrangle (Love, unpublished).

17.2 0.8 59.2

Togwotee Lodge on north side of road. Directly east of the lodge is Angle Mountain, part of the Precambrian and Paleozoic core of the Washakie Range of Laramide age, that was overlapped completely by Eocene volcaniclastic rocks and now is being exhumed.

17.6 0.4 58.8

Turn north to Togwotee scenic overlook. SUGGESTED STOP 4. Photo stop and rest area at the scenic overlook. Then return to main highway.

18.7 1.1 57.7

Ledges and dip slopes on left are steeply dipping Madison Limestone on the south flank of the Washakie Range. In this area, Paleozoic rocks are thrust southward onto Cretaceous rocks along the Buffalo Fork thrust fault which extends from here north-northwestward for

*Figure 12. Dinosaur- and mollusk-bearing siltstone interbedded with quartzite conglomerate in upper part of Harebell Formation in Rosies Ridge measured section. Collectors are American Museum of Natural History staff under the direction of M.C. McKenna and Wesley Gordon. View is of south side of cut along U.S. Highway 26/287. Photograph by J.D. Love, June 29, 1964.*

40 miles, finally disappearing under Yellowstone Lake. For a map showing the major structures in this area, see Love (1973, figure 1).

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 19.8 | 1.1 | 56.6 |

At mouth of canyon on north side of highway are outcrops of steeply dipping to overturned Triassic and Jurassic rocks.

20.3 0.5 56.1

To the southeast is Two Ocean Mountain, the farthest south remnant of the Wiggins Formation of middle to late Eocene age. The route goes near the north base of the mountain.

20.4 0.1 56.0

To north up slope in timber are red Triassic and Jurassic rocks overturned southward on the south flank of the Washakie Range. At mouth of ravine 100 yards to the northeast are outcrops of Mowry and Frontier Formations. This locality is north of milepost 30055 of the U.S. Forest Service. About 100 yards along the dirt road to the south is a gravel quarry in glacial ice margin debris. Across Blackrock Creek to the south, where the side road goes uphill, are outcrops of gray gently dipping Cody Shale—contrasting with steeply dipping Mesozoic rocks on north side of highway. Outcrops of Cody Shale continue along the south side of Blackrock Creek for the next two miles to the east.

21.4 1.0 55.0

Cliffs at stream level to south are gently dipping sandstones in the Frontier Formation. The original Yellowstone-Dubois highway crossed Blackrock Creek at this place.

22.1 0.7 54.3

Gray sandstone cliffs on north side of highway are in Frontier Formation.

22.3 0.2 54.1

On south side of Blackrock Creek and extending upstream for about one-fourth mile are white porcelanites, the lower marker zone in the Frontier Formation. The strata are folded into a sharp east-trending anticline.

23.1 0.8 53.3

On right, halfway up the south bank of Blackrock Creek is contact between black Mowry Shale below and gray massive basal sandstone of Frontier Formation above. Rolling bare hills extending south and southeast from Blackrock Creek have a thin veneer of green tuff in the Aycross Formation which overlaps gently dipping strata in the Mowry Shale and Frontier Formation. These Cretaceous rocks are folded into the Blackrock anticline which, in a well two miles south of the highway, was drilled to the Madison Limestone by the California Company in 1956. The following tops were reported by the company: Cloverly Formation, 1000 feet; Chugwater Formation, 2394; Phosphoria Formation, 3780; Tensleep Sandstone, 4013; Madison Limestone, 4668; total depth, 4879 feet. The geology from here east to Togwotee Pass is shown on the Togwotee Pass Quadrangle geologic map (Love, unpublished).

24.3 1.2 52.1

Road to south goes to a California Company dry hole. On skyline to north and east of highway are nearly horizontal layered gray and white volcaniclastic strata of the upper Eocene Wiggins Formation.

25.1 0.8 51.3

Dark brown cliffs are mafic volcaniclastic debris of uncertain correlation but of either middle or late Eocene age.

25.7 0.6 50.7

Dark green beds in left road cut have a K-Ar age of 47.8 million years (Smedes and Prostka, 1972, p. 30). For stratigraphic position and various interpretations of terminology, see section 5 in the accompanying Eocene correlation diagram (**Plate 1**, in back), which is reproduced from Love and others (1978, plate 5).

26.8 1.1 49.6

Togwotee Pass, elevation 9544 feet, on Continental Divide. The horizontally layered gray and white rocks on Sublette Peak to the northeast and similar rocks on Two Ocean Mountain to the southwest are part of the Wiggins Formation of late Eocene age. The green treeless badlands south and west of Togwotee Pass are the upper part of the Aycross Formation. McKenna (1972, p. 92) reported an extensive fossil vertebrate fauna of Bridger A-B age from a site about 1000 feet west of Togwotee Pass. See section 5 in the Eocene correlation diagram (**Plate 1**).

27.0 0.2 49.4

Small glacial lake on north side of road.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 27.3 | 0.3 | 49.1 |

Volcaniclastic strata in road cut.

| | | |
|---|---|---|
| 27.4 | 0.1 | 49.0 |

Road to east goes to Wind River Lake (also called Sublette Lake), dimly visible through trees. This road is the old Atlantic-Yellowstone-Pacific (AYP) highway, which now is a one-way road (going west) from Brooks Lake.

| | | |
|---|---|---|
| 28.0 | 0.6 | 48.4 |

Lava Mountain to south is composed of nearly 1000 feet of horizontal lava flows. The age of one of these is reported by Rohrer and Obradovich (1968, p. A27) to be 480,000 ± 60,000 years. The little red knob on the summit (better visible to those heading west) is composed of only slightly lithified scoria that is probably very young.

| | | |
|---|---|---|
| 29.0 | 1.0 | 47.4 |

Looking through gap in trees to the south are ragged summits of Pilot Butte, which is a post-Aycross intrusive body of vogesite, an unusual potash-rich rock (R. S. Houston, written communication: study of thin section Wyo-285, collected by Love in 1945). This rock has a K-Ar age of 3.4 ± 0.06 million years (Rohrer and Obradovich, 1978).

| | | |
|---|---|---|
| 29.8 | 0.8 | 46.6 |

Straight ahead (for travelers headed to Dinwoody) are Pinnacle Buttes in the Wiggins Formation on the east side of Brooks Lake (**Figure 13**). The geology of this area, and for the next ten miles along the highway to the southeast, was mapped by Rohrer (1966). Potassium-argon ages of the Wiggins here range from 46.2 million years at the base to 45 million years at the top (see section 7, **Plate 1** for stratigraphic position of samples and terminology of underlying section; see also Rohrer and Obradovich, 1969, p. B57-B62).

| | | |
|---|---|---|
| 30.3 | 0.5 | 46.1 |

Directly south is the high flat summit of the Wind River Range in the vicinity of Union Peak. This summit surface, which was probably at the upper limit of Tertiary fill, is variously called the Summit (or Subsummit) surface, Wind River peneplain, or Fremont surface.

| | | |
|---|---|---|
| 32.7 | 2.4 | 43.7 |

Straight ahead (for those headed eastward) on skyline is site of Rohrer's Pinnacle Buttes measured section.

| | | |
|---|---|---|
| 33.0 | 0.3 | 43.4 |

Good view of Pinnacle Buttes to the northeast.

| | | |
|---|---|---|
| 34.1 | 1.1 | 42.3 |

Pinnacle Buttes on skyline to northeast.

| | | |
|---|---|---|
| 34.6 | 0.5 | 41.8 |

Road to north goes to Brooks Lake and on to the west as a one-way road, entering main highway at Wind River Lake.

| | | |
|---|---|---|
| 35.1 | 0.5 | 41.3 |

On south side of road, falls of Brooks Lake Creek cut through Aycross Formation. Hard ledge forms lip of falls.

| | | |
|---|---|---|
| 35.9 | 0.8 | 40.5 |

Variegated beds on north side of road are considered to be in the Wind River Formation of Rohrer (1966), but may be equivalent to the Aycross Formation as shown on **Plate 1**.

| | | |
|---|---|---|
| 37.9 | 2.0 | 38.5 |

Beginning here and for next three miles to southeast, road cuts on northeast side of road show intermittent exposures of black and brown shales that are radioactive and contain small amounts of uranium, selenium, molybdenum, and vanadium. These are in the Wind River Formation as mapped by Rohrer (1966).

| | | |
|---|---|---|
| 39.6 | 1.7 | 36.8 |

Tie Hack Memorial Monument.

| | | |
|---|---|---|
| 39.9 | 0.3 | 36.5 |

The lowest clearcut to southwest is one of the first in Wyoming and is approximately 60 years old. It has been hand-planted several times and regeneration remains slow. Other clearcuts, chiefly on the landslide debris of Eocene rocks, are younger, and trees are likewise slow to regenerate.

| | | |
|---|---|---|
| 41.1 | 1.2 | 35.3 |

Wind River Ranch to south.

*Figure 13. Layered volcaniclastic rocks in the Wiggins Formation exposed on the south face of Pinnacle Buttes, about two miles east of Brooks Lake. Dark beds are volcanic conglomerate and white ones are tuff. Thickness of rocks shown is about 800 feet. The upper part has a K-Ar age of 45 million years. Note cross sections of huge dark irregular blocks in upper center. Photograph by J.D. Love, September 16, 1969.*

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 42.2 | 1.1 | 34.2 |

Lumpy hills on south side of Wind River are a mixture of landslide and glacial debris.

| | | |
|---|---|---|
| 42.8 | 0.6 | 33.6 |

East boundary of Shoshone National Forest. Carbonaceous shales on north side of road are radioactive and contain small amounts of uranium, selenium, molybdenum, and vanadium. For stratigraphic position, see bottom of section 7, **Plate 1**, horizon L73-281-2.

| | | |
|---|---|---|
| 43.5 | 0.7 | 32.9 |

Road south across Wind River goes to Miami University geology field camp.

| | | |
|---|---|---|
| 45.8 | 2.3 | 30.6 |

Bridge over Long Creek. Hat Butte, due south, is composed of Eocene-age tuffs overlying Paleozoic rocks that dip northeastward on the flank of the Wind River Range. The nearly horizontal beds on the north side of the highway for the last five miles are greenish-gray and drab tuffaceous facies of the Wind River Formation (see **Plate 1**, section 7; also Keefer, 1957). Lumpy topography on south side of Wind River is largely debris of the Pinedale Glaciation.

| | | |
|---|---|---|
| 46.9 | 1.1 | 29.5 |

On east side of road, just above power line is one of

the quarries in the Wind River Formation from which an extensive flora has been collected. This is an important site, described by Keefer (1957, p. 191) and in more detail by MacGinitie (1969).

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 47.2 | 0.3 | 29.2 |

Pinedale till in road cuts marks junction of ice that flowed down Wind River valley with that which flowed down the Du Noir River valley.

47.8 0.6 28.6

To east is broad flat-bottomed valley of Du Noir River. Fluted sides at several levels were developed by different episodes of glaciation that scoured the soft variegated strata of the Wind River Formation. To the north is the Ramshorn, a prominent jagged peak on the skyline. It is composed of nearly horizontal stratified volcanic conglomerates and tuffs in the Wiggins Formation of late Eocene age.

48.7 0.9 27.7

SUGGESTED STOP 5. Junction of U.S. Highway 26/287 and Union Pass road. Pull into gravel area on south side of highway to observe local and regional geology.

49.0 0.3 27.4

Union Pass marker monument. The military road went from here southwestward across the Continental Divide and into Jackson Hole and the Green River Basin.

49.9 0.9 26.5

To south, across Wind River and up the north-flowing ravine, are two skid roads and several inconspicuous cabins that mark the site of a coal mine in the Wind River Formation. This is an unusual occurrence of coal, because it accumulated in a narrow steep-sided valley cut in the northeast-dipping Tensleep and Phosphoria Formations. Keefer (1957, p. 216) measured a 24-inch coal bed within an 8-foot lignite and gray shale sequence. To south-southeast across Wind River are bare ledges of the Phosphoria Formation.

50.4 0.5 26.0

Outcrops of the Phosphoria Formation are on both sides of highway. Those on the north side contain several radioactive black shales and phosphate beds. This section was measured by Condit in 1913 (quoted by Sheldon, 1963, p. 220), but no analyses were given. It was remeasured and sampled by Love in 1973 (analyses published by Prostka and others, 1974, table 6, p. 28). Maximum values are, in parts per million: uranium, 310; silver, 3; chromium, 500; zinc, 1000; and in percent: $P_2O_5$, 31.8. The thickest phosphate bed is about two feet thick.

50.8 0.4 25.6

Stoney Point (**Figure 14**). The contact between the Tensleep Sandstone (Early Pennsylvanian here) and Phosphoria Formation (Middle Permian) is marked on the photograph and can be identified about one-third of the way up the cliff, at the base of a pebbly sandstone.


*Figure 14. Contact between Phosphoria Formation (Pp) and Tensleep Sandstone (IPt) on north side of highway cut at Stoney Point. Photograph by W.R. Keefer, 1953.*

51.0 0.2 25.4

To the north, the Wind River Formation laps across northeast-dipping Phosphoria Formation. For about one-half mile to the east one can see a dramatic facies change: drab, non-variegated claystones and silty sandstones grade eastward into brightly variegated badlands at mileage 51.5. These badlands have yielded lower Eocene fossil mammals typical of the Lost Cabin (upper) Member of the Wind River Formation (for fossil list, see Keefer, 1957, figure 69, locality 2).

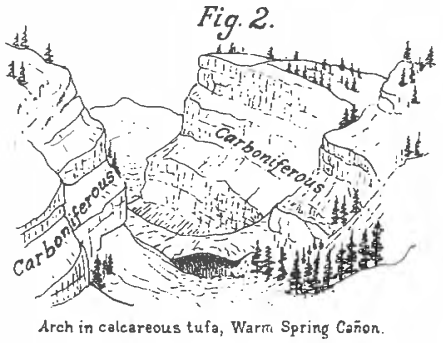
52.5 1.5 23.9

To southwest across river, Warm Spring Canyon cuts through the Madison Limestone on the east flank of the Wind River Range. Several terrace levels on the

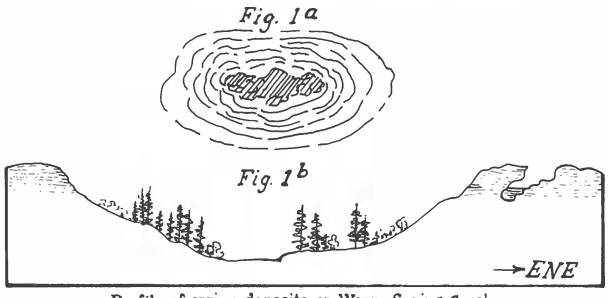
southeast side of the canyon are held up by travertine deposits with a maximum thickness of more than 500 feet. Some travertine is still being precipitated at creek level by warm springs. Orestes St. John, with the Hayden Survey (in Hayden, 1883, p. 266-269 and plate 49), described and figured (**Figure 15**) the Warm Spring Canyon thermal complex. The temperature then and 100 years later was the same, 184°F (29°C) (Breckenridge and Hinckley, 1978, p. 24). A wooden flume was built through the canyon in the 1920s to carry railroad ties to the Wind River. Remnants of it are still preserved, clinging to the canyon walls.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 52.8 | 0.3 | 23.6 |

Gravel road to south goes to Warm Spring Ranch. Looking straight down this road one can see northeasterly dipping red Chugwater Formation of Triassic age, unconformably overlapped by nearly horizontal travertine at the level of the prominent terrace.



Arch in calcareous tufa, Warm Spring Cañon.



Profile of spring deposits on Warm Spring Creek.
Fig. 1a Outline of orifice of ancient spring, 15 by 50 feet.
Fig. 1b Section of ancient spring, partially filled with water.

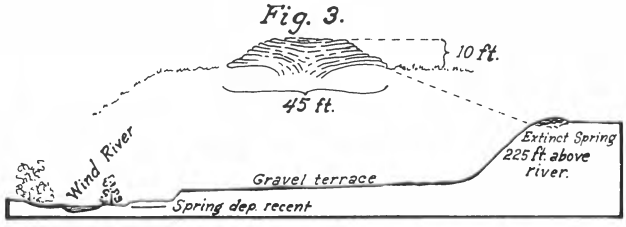



*Figure 15. Sketches of travertine deposits and associated strata, Warm Spring Creek Canyon. Reproduced from Plate XLIX by St. John, in Hayden (1883).*

| | | |
|---|---|---|
| 53.6 | 0.8 | 22.8 |

To southwest is a large landslide cutting into prominent terrace. Warm springs emerge within the slide and have cemented slide debris with travertine.

| | | |
|---|---|---|
| 55.4 | 1.8 | 21.0 |

Road to airport, which is on top of terrace to south, across Wind River.

| | | |
|---|---|---|
| 55.9 | 0.5 | 20.5 |

To southwest, across river below terrace edge, are white cemented layers of travertine, unconformably overlying northeastward-dipping red Chugwater Formation.

| | | |
|---|---|---|
| 56.8 | 0.9 | 19.6 |

Gray cliffs to northeast are bleached Nugget Sandstone, here probably of Triassic age.

| | | |
|---|---|---|
| 57.1 | 0.3 | 19.3 |

Redbeds in road cut to north are part of Chugwater Formation.

| | | |
|---|---|---|
| 57.7 | 0.6 | 18.7 |

Dubois, a lively cattle, lumbering, and tourist center. Variegated Wind River Formation to northeast unconformably overlaps red Chugwater Formation and probably derives much of its red color from the Chugwater.

| | | |
|---|---|---|
| 58.3 | 0.6 | 18.1 |

Nugget Sandstone to north at junction of Horse Creek road with Main Street. The cave carved into the Nugget has been used at various times as a bar and as a jail. Welty's store on right. SUGGESTED REST AND REFRESHMENT STOP 6.

| | | |
|---|---|---|
| 58.5 | 0.2 | 17.9 |

Turn south (or west, if traveling towards Jackson).

| | | |
|---|---|---|
| 58.7 | 0.2 | 17.7 |

To south-southwest, across river, are bare, red, dip slopes of Chugwater Formation. The orange-colored badlands are in the Popo Agie Member of the Chugwater and contain fragments of labyrinthodont amphibians. Fossils of any kind are rare in the Chugwater Formation. Colbert (1957, p. 89-93) discussed the forms found in this part of the Wind River Basin. The orange-colored badlands contain abundant

rosettes of analcime (sodium-aluminum silicate), which are widespread at and near the top of the Popo Agie Member.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 59.1 | 0.4 | 17.3 |

To south-southwest, the gray cliffs across the river are bleached Nugget Sandstone. These are exposed for the next half mile to the east.

60.8 1.7 15.6

Badlands on north side of Wind River are all part of the Wind River Formation. These strata are exposed continuously to the north for the next five miles.

61.7 0.9 14.7

Road cuts are in Pinedale terminal moraines emerging from Jakeys Fork Canyon in the Wind River Range.

62.2 0.5 14.2

Bridge across Jakeys Fork. To southwest, canyon and lateral moraines are visible. St. John (in Hayden, 1883, p. 236-244) measured sections and sketched panoramas and cross sections in each major canyon, including Jakeys Fork, along the northeastern flank of the Wind River Range from Warm Spring Creek south to the North Fork of Little Wind River.

63.4 1.2 13.0

Bridge across Torrey Creek. Upstream, out of sight, is a series of glacial lakes dammed by recessional moraines.

63.8 0.4 12.6

Road cuts are in Sundance and Morrison Formations tilted steeply eastward.

64.2 0.4 12.2

To the north, the highest red cliffs in the badlands are Indian Meadows Formation of earliest Eocene age thrust southwestward onto the Lost Cabin Member of the Wind River Formation (lower Eocene). At the base of the red cliffs is a wedge of gray sandstone in the Frontier Formation on the overriding thrust plate. From the thrust fault to river level (about 600 feet) all the variegated badlands are part of the Wind River Formation.

65.4 1.2 11.0

To the northeast, morainal debris is present on the east side of Wind River. This is one of only a few places where glacial debris extends to the east side of the river. These occurrences are useful in determining the amount and rate of erosion since this ice advance.

67.0 1.6 9.4

Bridge across Wind River. Badlands to northeast contain lower Eocene fossil mammals in the Wind River Formation.

67.4 0.4 9.0

Steeply dipping walls to southwest across river are sandstone and limestone in the marine Sundance Formation. It is unconformably overlain by nearly horizontal red conglomerates in the Wind River Formation.

68.7 1.3 7.7

Boulder beds on both sides of Wind River are morainal deposits into which Wind River has been incised.

69.4 0.7 7.0

Gray dip slopes to west are bleached Nugget Sandstone.

69.6 0.2 6.8

High flat butte to west is capped by travertine deposited unconformably on Chugwater Formation.

70.1 0.5 6.3

Nugget Sandstone to northeast, east, and southeast.

70.2 0.1 6.2

Bridge across Wind River.

70.3 0.1 6.1

At road level to south is thin-bedded travertine.

70.6 0.3 5.8

For the next mile on the east side of Wind River are gray ledges of the Sundance Formation, dully variegated Morrison Formation, brightly variegated and lilac-colored beds in the Cloverly Formation, capped by rusty beds member of Cloverly Formation.

71.2 0.6 5.2

On skyline to northeast is horizontal Wind River For-

mation unconformably overlapping Jurassic and Cretaceous strata.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 71.7 | 0.5 | 4.7 |

Pink and tan cliffs are unbleached Nugget Sandstone underlain by orange and red analcime-rich claystones in the Popo Agie Member of the Chugwater Formation.

72.4 0.7 4.0

To west is the Alcova Limestone Member of the Chugwater Formation, about one foot thick, near the top of the lowest cliff. Red cliffs directly south are part of the Red Peak Member of the Chugwater Formation. This is known as the Red Grade locality. It is the site of the Red Grade measured section (Love and others, 1947, p. 10-17; Love, Johnson, and others, 1945; Love, Thompson, and others, 1945; Love, Tourtelot, and others, 1945), many stratigraphic studies by M.D. Picard and associates, and paleomagnetic studies by Picard and P.N. Shive. Here the Chugwater Formation is about 1300 feet thick.

72.9 0.5 3.5

Horizontal beds up canyon to south are travertine deposits of Quaternary age unconformably overlapping east-dipping Chugwater redbeds.

73.9 1.0 2.5

Red Rock Lodge. Across river to north is a pink to tan cliff of Nugget Sandstone, 135 feet thick, and completely exposed (**Figure 16**). At the base of the cliff, the softer green, red, and yellow strata are part of the Popo Agie Member of the Chugwater Formation. The redbeds overlying the Nugget are part of the Gypsum Spring Formation of Middle Jurassic age, from which the lower thick gypsum bed has been leached at and near the surface. The gray ledges above the red are the Sundance Formation of Middle and Late Jurassic age. To the southeast, Nugget Sandstone extends up toward skyline. The flat surface seen to the south is capped by horizontal travertine interlayered with ash at the highest skyline exposures. This ash, "Pearlette type O," has a K-Ar age of about 600,000 years at this site (G.A. Izett, written communication, 1977). Thus, it is possible to compute the rate of post-ash downcutting of Wind River. Using the position of this ash and a similar one a mile east-northeast, the average rate of downcutting would be about one foot per 1000 years during the last 600,000 years.

74.7 0.8 1.7

The colorful panorama shown in **Figure 17** is seen to the north-northwest. This is the upper part of the Red Grade measured section (Love, Tourtelot, and others,

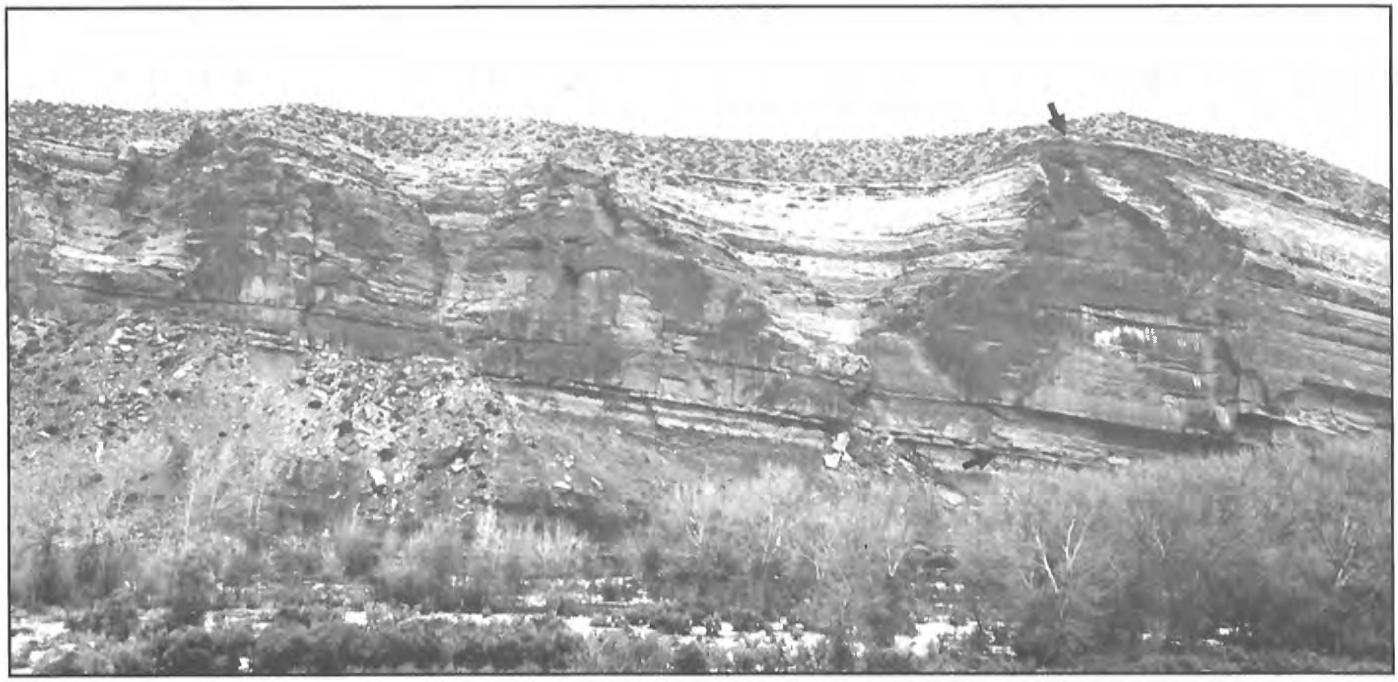


*Figure 16. View northeast at entire 135 feet of Nugget Sandstone (between arrows) in Red Grade measured section. Evenly bedded red, green, and orange strata below Nugget are in the upper part of the Popo Agie Member of the Chugwater Formation. Wind River flows along base of cliff. Photograph by J.D. Love, November, 1944.*

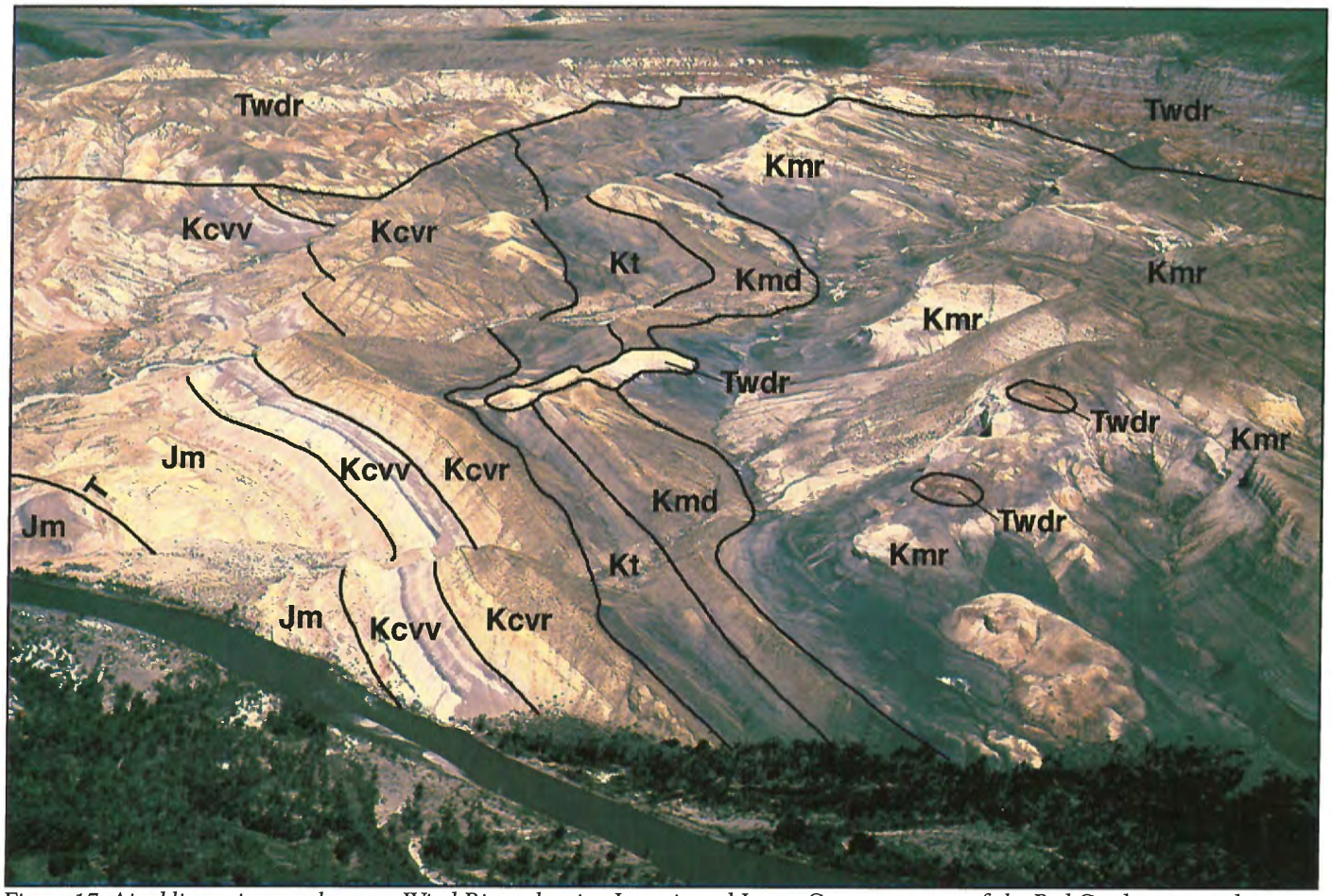



*Figure 17. Air oblique view north across Wind River, showing Jurassic and Lower Cretaceous part of the Red Grade measured section. The nearly horizontal Wind River Formation unconformably overlaps the Cretaceous rocks at the top of the photograph. Formations indicated are: Jm - Morrison Formation (Upper Jurassic); the Lower Cretaceous units Kcvv - variegated part of the Cloverly Formation, Kcvr - rusty beds member of the Cloverly Formation, Kt - Thermopolis Shale, Kmd - Muddy Sandstone Member of the Thermopolis Shale, and Kmr - Mowry Shale; and Twdr - the Lower Eocene Wind River Formation. A thrust fault (T on overriding block) is at lower left. Photograph by W.B. Hall, T.H. Walsh, and J.D. Love, July 7, 1974.*

the Sundance Formation are overlain by dully variegated claystones and sandstones in the Morrison Formation. Overlying the Morrison is brightly variegated red, lilac, and white claystone capped by the rusty beds member of the Cloverly Formation. Overlying the rusty beds member is the black Thermopolis Shale and at about straight north the gray-banded Mowry Shale is visible. On the northern skyline, the candy-striped red and white badlands are in the horizontal Wind River Formation.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Junction | Increment | Cumulative from Dinwoody |
| 76.4 | 1.7 | 0.0 |

SUGGESTED STOP 7. Turnaround point. This is the farthest southeast stop and the end of the second segment of the field trip. From here travelers may return to Jackson and Teton Village or continue on to Lander or Riverton. Go through fence and stand on top of knoll 30 feet north of fence. You are standing on part of the moraine of Pinedale age that emerged from Dinwoody Canyon to the southwest and spread out on the floor of the Wind River Basin. An extensive panorama of complex Paleozoic, Mesozoic, Tertiary, and Quaternary stratigraphy, structure, and geologic history can be seen. The annotated photographs (**Figures 18-24**) serve as guides for the following discussion. Beginning with the Wind River Mountains to the southwest and west, the bare part of the skyline is composed of northeast-dipping Madison Limestone. The black zone of trees marks the outcrops of Amsden and Tensleep Formations. The bare flatiron-shaped lower dip slopes are Phosphoria Formation. The redbeds we have just passed are Chugwater Forma-


*Figure 18. View west from Stop 7, toward Wind River Range on skyline. Indicated are: Mm - Madison Limestone (Mississippian); PPt - Tensleep Sandstone (Pennsylvanian); Pp - Phosphoria Formation (Permian); TRc - Chugwater Formation (Triassic); JTRn - Nugget Sandstone [Jurassic(?) and Triassic(?)]; and sites of Pleistocene ash. Photograph by J.D. Love, October 25, 1979.*

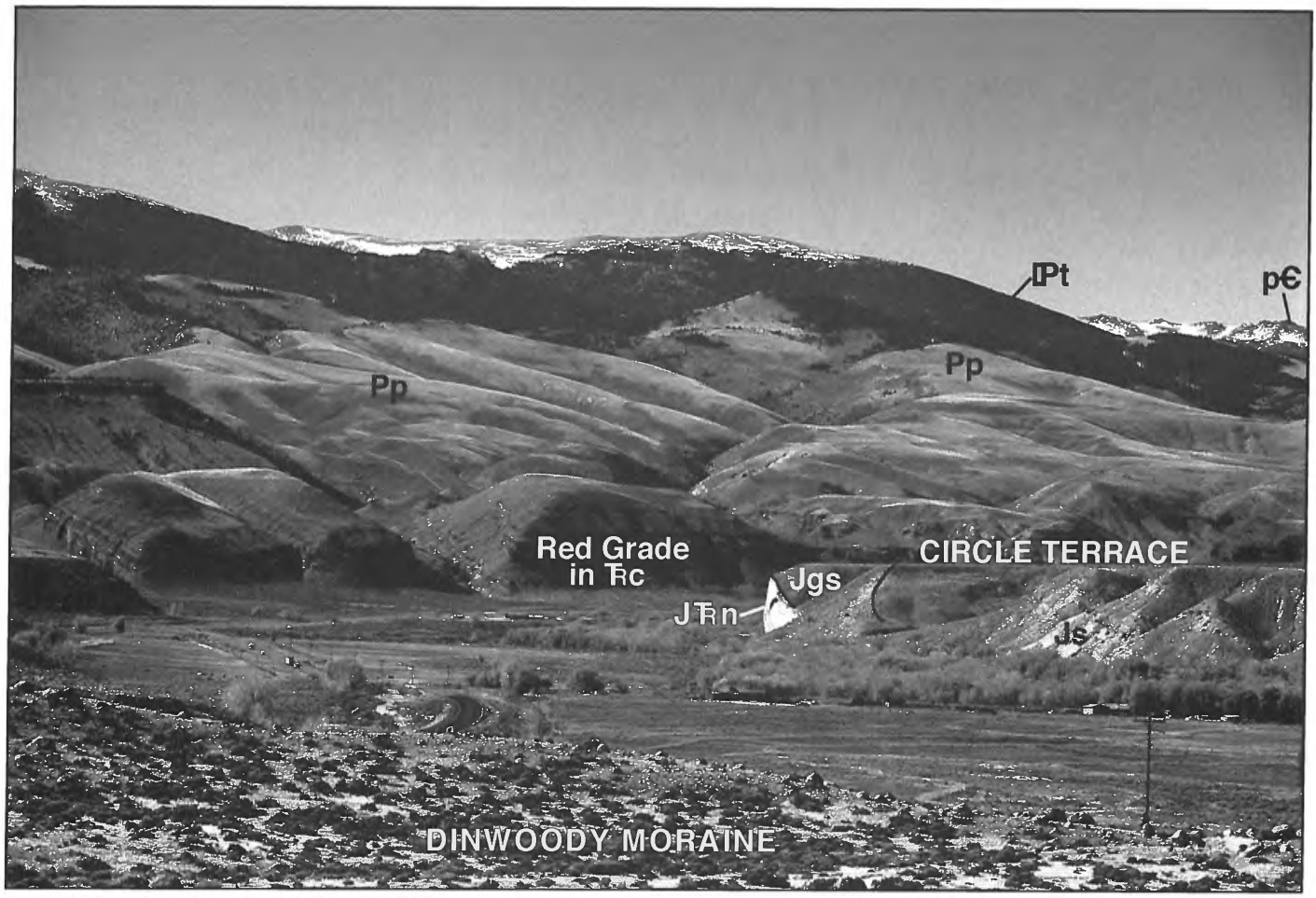



*Figure 19. View west-northwest from Stop 7, toward Wind River Range on skyline. Indicated are: pC - Precambrian rocks on Union Peak in the core of the Wind River Mountains; IPt - Tensleep Sandstone (Pennsylvanian); Pp - Phosphoria Formation (Permian); Trc - Chugwater Formation (Triassic); JTrn - Nugget Sandstone [Jurassic(?) and Triassic(?)]; and Jgs - Gypsum Spring Formation and Js - Sundance Formation, both of Jurassic age. Photograph by J.D. Love, October 25, 1979.*

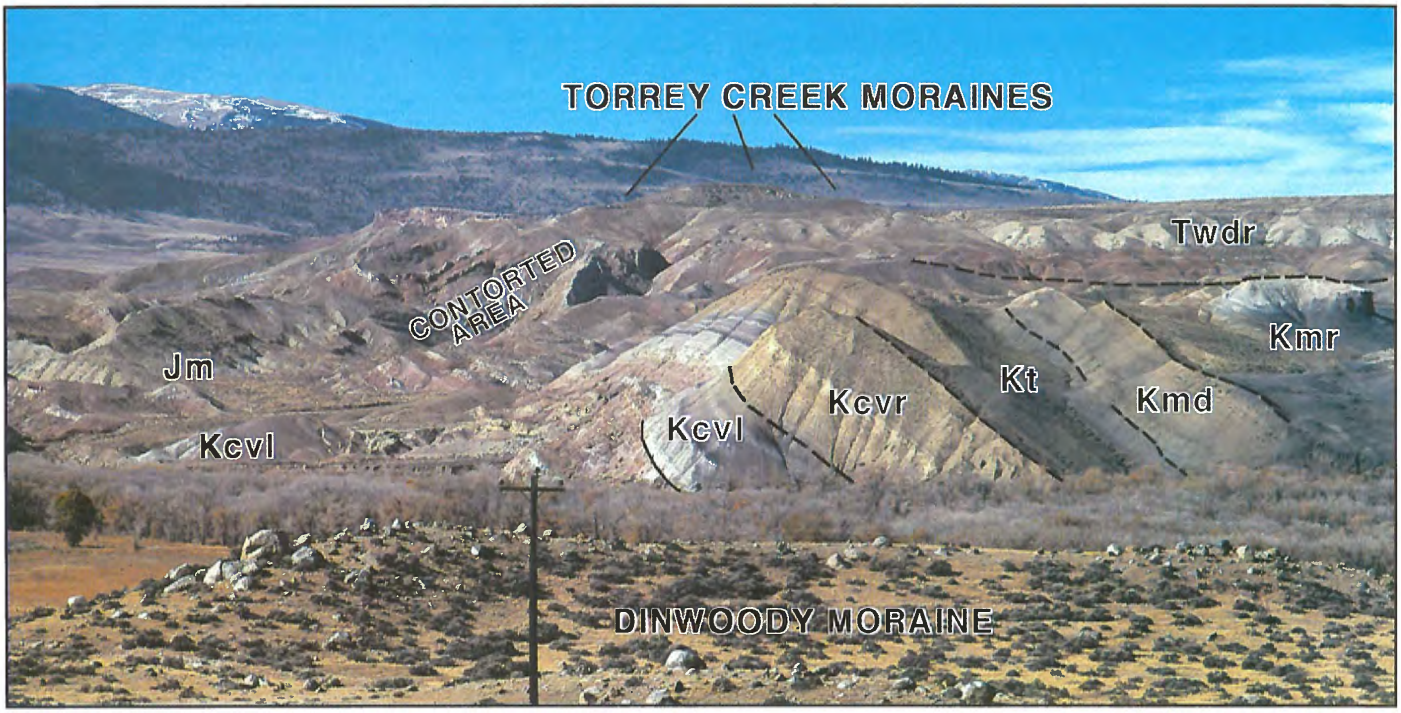



*Figure 20. View northwest from Stop 7. Wind River Range are on left skyline. Indicated are: Jm - Morrison Formation (Jurassic); Kcvl - lilac claystone zone in Cloverly Formation, Kcvr - rusty beds member in Cloverly Formation, Kt - Thermopolis Shale, Kmd - Muddy Sandstone Member of Thermopolis Shale, and Kmr - Mowry Shale, all of Cretaceous age; and Twdr - Wind River Formation of Eocene age. Photograph by J.D. Love, October 25, 1979.*

lower dip slopes are Phosphoria Formation. The redbeds we have just passed are Chugwater Formation. The two ash localities are shown on **Figure 18**, as well as the overlying travertine and gravel surface that has been incised during the last 600,000 years.

Coming clockwise to the west-northwest, is the panorama shown in **Figure 19**. The rocks on the far skyline are Precambrian granite and gneiss in the Union Peak area, part of the core of the Wind River Range. The cliff in the right center is the Nugget Sandstone shown in **Figure 16**. The prominent terrace about 200 feet above Wind River is the Circle terrace of Blackwelder (1915). The Jurassic and Lower Cretaceous rocks just across Wind River to the northwest (**Figure 20**) comprise one of the most colorful sections in this region that can be seen from the highway. In the distance, the candy striped horizontal badlands are part of the Wind River Formation unconformably overlapping the Cretaceous and older rocks (**Figures 21** and **22**). To the north and north-northeast on the skyline is our only glimpse of the Aycross Formation, of middle Eocene age, on the South Table (**Figures 23** and **24**).

Just across Wind River is a series of northwest-trending thrust faults, the nearest of which is clearly visible. It is the Wind Ridge thrust (**Figures 22** and **24**; Love, 1939), which placed the Frontier Formation and overlying basin facies of the Indian Meadows Formation (the dark red ragged cliffs) on top of the horizontal Wind River Formation. Thus, it is a post-early Eocene thrust, as are all the others in this general area. Black dumps of two coal mines are plastered across the Wind River Formation, but the coal is actually along the fault plane in the Frontier Formation. On the lumpy skyline just off the left side of **Figure 23** are several of ten or more masses (klippen?) of Paleozoic rocks emplaced by thrusting or gravity sliding; these are chiefly Bighorn Dolomite (Ordovician) and Madison Limestone (Mississippian) resting on bright salmon-red strata of the Indian Meadows Formation, dull-gray Cody Shale, and overlain by more variegated strata of the Indian Meadows. For detailed map, see Love (1939, plate 17).

The far skyline peaks to the northeast are the Wiggins Formation in the Absaroka Range. This sequence overlaps the southeast end of the Washakie Range (**Figure 25**), which is marked by the high bare summit of Black Mountain. To the left of Black Moun-

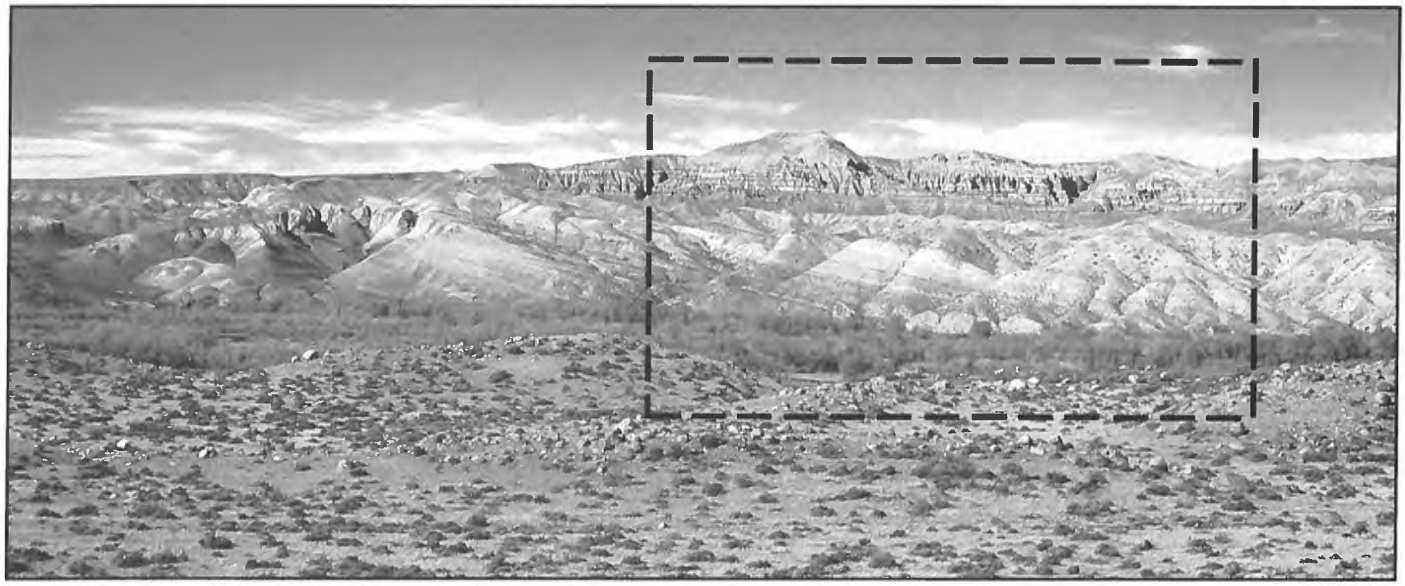


*Figure 21. View north-northwest from Stop 7. Standing on Dinwoody moraines that form bench overlooking Wind River in middle foreground. Dashed outline indicates area shown in Figure 22. Photograph by J.D. Love, October 25, 1979.*

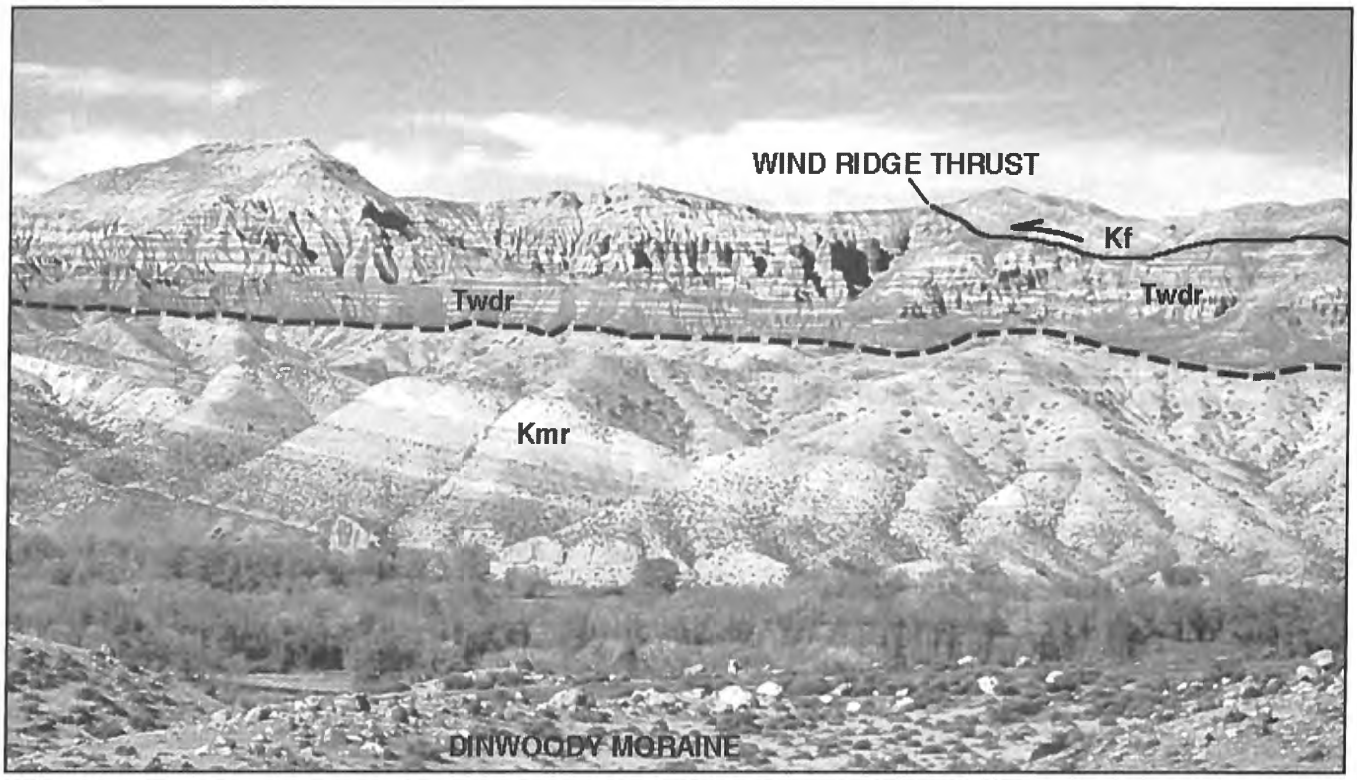



*Figure 22. Close-up view of a part of Figure 21. Indicated are: Kmr - Mowry Shale (Cretaceous); unconformably overlain by Twdr - Wind River Formation (Eocene). Thrust fault on the Wind River Formation has Kf - Frontier Formation (Cretaceous) on the upper thrust plate. Photograph by J.D. Love, October 25, 1979.*

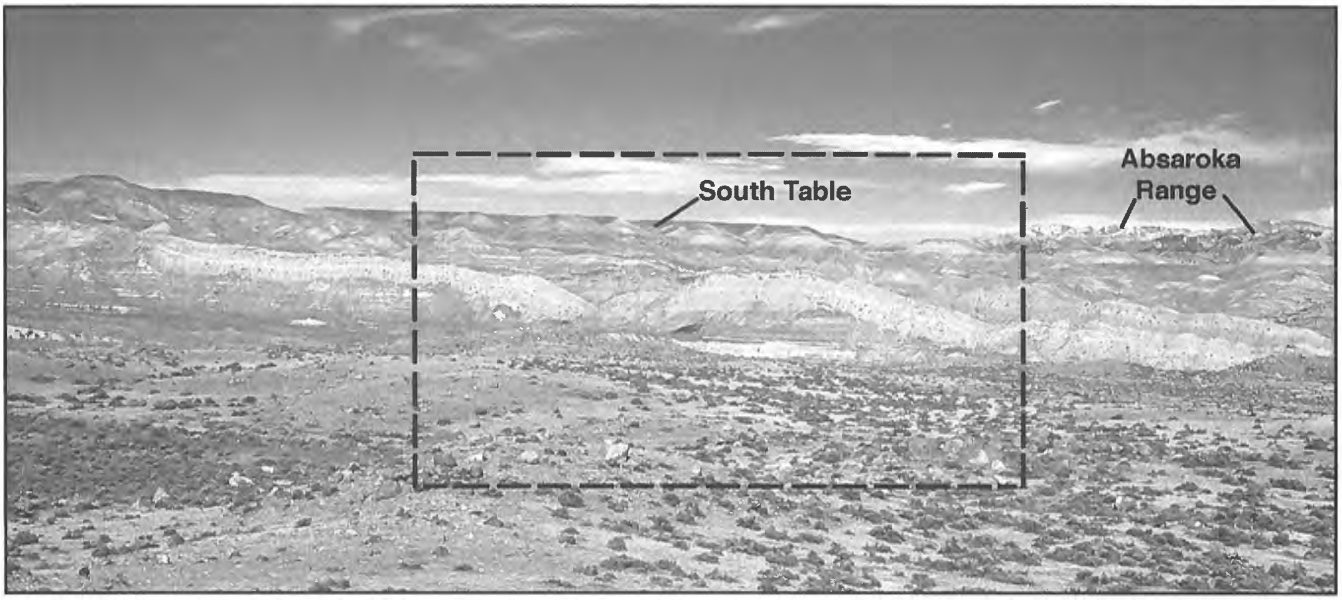



*Figure 23. View north from Stop 7. South Table is also known on the 1906 topographic map as Coulee Mesa, on the 1967 topographic map as Lower Table, and by some residents as South Mesa. Dashed outline indicates area shown in Figure 24. Photograph by J.D. Love, October 25, 1979.*

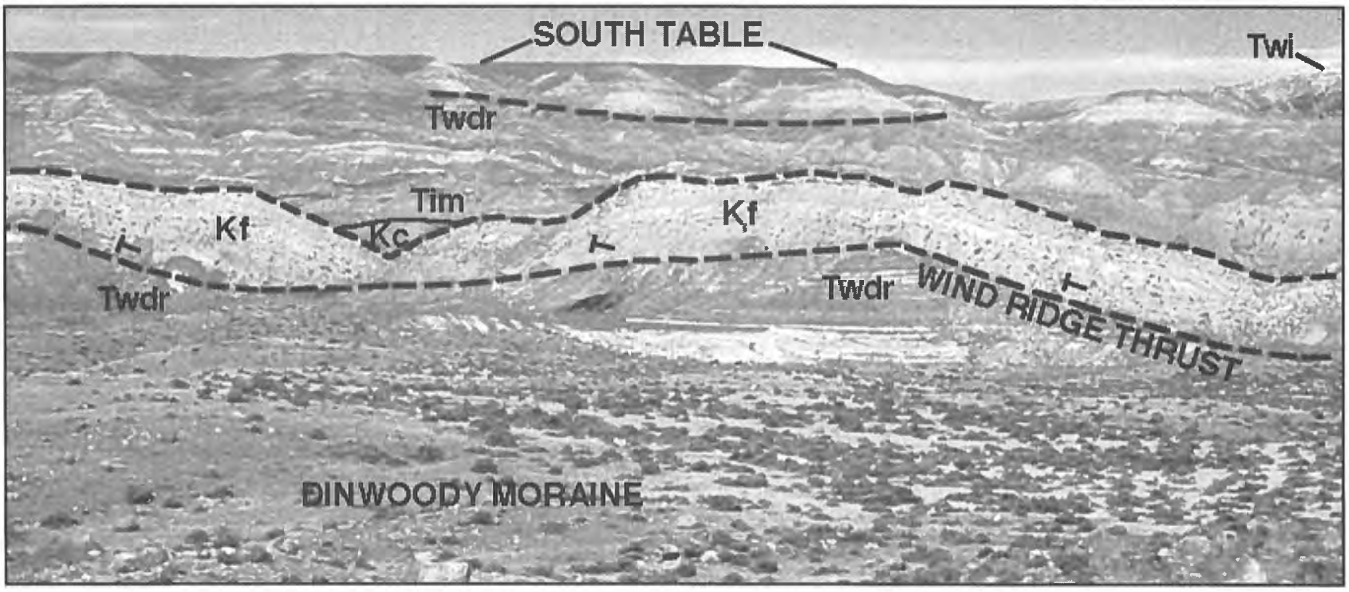



*Figure 24. Close-up view of a part of Figure 23. Indicated are: Twdr - Wind River Formation (lower Eocene), overridden in the middle distance by Kf - Frontier Formation (Cretaceous). The Frontier is overlain by Kc - Cody Shale (Cretaceous). Other units are: Tim - Indian Meadows Formation (lowest Eocene); Tac - Aycross Formation (middle Eocene); Twi - Wiggins Formation (middle and upper Eocene). The horizontal T is on the upper thrust plate. Black spot in middle of photograph is mine dump from an abandoned coal mine in the Frontier Formation directly above the thrust fault. Photograph by J.D. Love, October 25, 1979.*

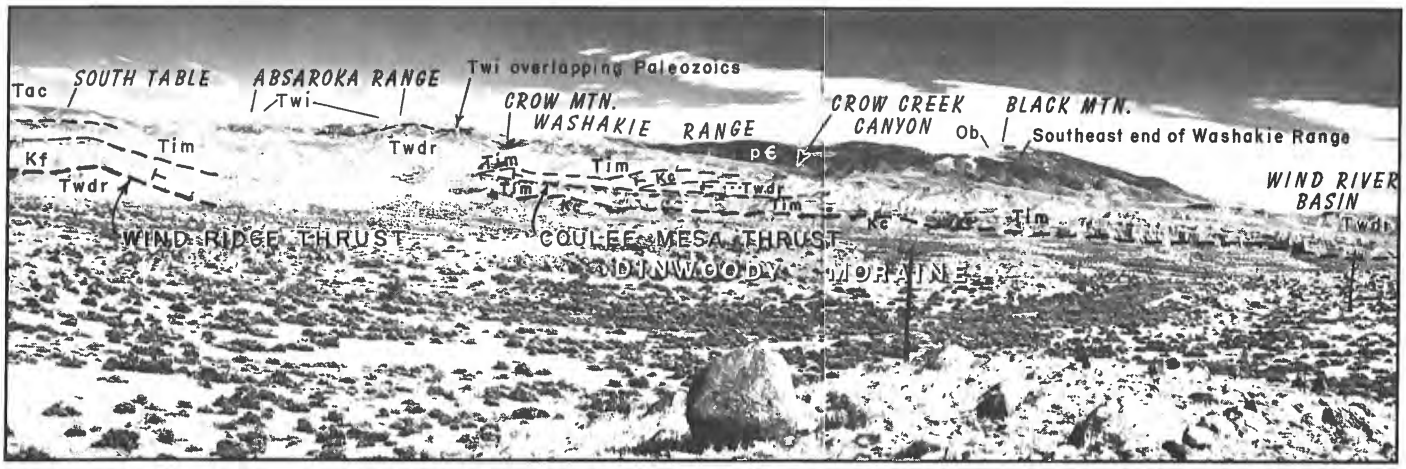



*Figure 25. Panoramic view northeast from Stop 7 showing an intricate series of lower Eocene thrust faults and their relation to the Washakie Range and the Wind River Basin. Also shown is the overlapping of the upper Eocene volcaniclastic rocks of the Absaroka Range onto Precambrian and Paleozoic rocks near the southeast end of the Washakie Range. Indicated are: Kf - Frontier Formation and Kc - Cody Shale, both of Cretaceous age; Tim - Indian Meadows Formation, Twdr - Wind River Formation, Tac - Aycross Formation, and Twi - Wiggins Formation, all of Tertiary age; Ob - Ordovician Bighorn Dolomite; and pC - Precambrian granite. The horizontal T is on upper thrust plate. Photograph by J.D. Love, October 25, 1979.*

tain is Crow Creek Canyon, about 1000 feet deep, cut in Precambrian granite. In the middle distance, the Coulee Mesa thrust puts gray Cody Shale on variegated Wind River and bright red Indian Meadows Formations. To the right of Black Mountain, on the lower skyline, all rocks are part of the Wind River Formation in the main Wind River Basin. To the south, the lumpy topography is on Pinedale moraines left by ice that emerged from Dinwoody Canyon in the Wind River Mountains.

Retrace route to Moran Junction to continue this road log (see **Figures 1** and **9**). Reset both interval and cumulative mileages to zero.

# Moran Junction to Moose

| Mileage | | |
|---|---|---|
| Cumulative from Moran Jct. | Increment | Cumulative from Moose |
| 0.0 | 0.0 | 27.1 |

Moran Junction. Turn right (north) on U.S. Highway 89/287.

| | | |
|---|---|---|
| 0.2 | 0.2 | 26.9 |

East Entrance, Grand Teton National Park. Lumpy hills north of road are morainal debris.

| | | |
|---|---|---|
| 0.8 | 0.6 | 26.3 |

Bridge across Pacific Creek. Placer gold has been found in quartzite gravels derived from Cretaceous and Paleocene rocks upstream from this bridge. Bluff to east is part of Mesaverde Formation. On north side of highway west of Pacific Creek, is Lozier Hill, composed of gold-bearing quartzite conglomerate in the lower part of the Pinyon Conglomerate, here of latest Cretaceous and Paleocene age. The geology for the next 8.5 miles is on the geologic map of the Moran Quadrangle (Love, unpublished).

| | | |
|---|---|---|
| 1.2 | 0.4 | 25.9 |

Road to northeast goes up Pacific Creek to the Teton National Forest-Teton Wilderness; road stops at edge of wilderness.

| | | |
|---|---|---|
| 2.5 | 1.3 | 24.6 |

Scenic turnoff to south at wildlife park-national environmental study area. Mount Moran is the nearly flat-topped peak on the skyline to the west (**Figure 26**), and has an elevation of 12,605 feet. The vertical black dike, 100-150 feet wide, is diabase. Its age is controversial, but may be about 765 million years. It probably is not much younger because it is unconformably overlain by the nearly horizontal Flathead Sandstone of Middle Cambrian age. The Flathead forms the rounded summit above and to the north of the dike. The dike intrudes migmatitic biotite gneiss which is older than 2700 million years. Falling Ice glacier is on the left and Skillet glacier on the right. Bivouac Peak, 2.5 miles north of Mount Moran, likewise is capped by Flathead Sandstone. These occurrences are especially useful in structure contouring the Cambrian-Precambrian contact and in determining the amount of post-Precambrian erosion of the Teton Range. On the farthest north part of the range, Paleozoic rocks can be seen lapping around the Precambrian core.

Rising 900 feet above the valley floor to the southwest is the triangular timber-covered Signal Mountain. A scenic road goes all the way to the top. The prominent ledge on the north and east sides is the Huckleberry Ridge Tuff, 1.9 million years old, which was discussed at Stop 3. A near view of the tuff will be available at the south end of the Jackson Lake Dam. Signal Mountain was overridden by at least 2000 feet of ice which moved southward in this area, shaped the mountain, and left a mantle of glacial debris on the summit and sides. Underneath the Huckleberry Ridge Tuff is glacial debris from a very old (more than two million years) glaciation about which we know very little.

The north spur of Signal Mountain is composed of the Conant Creek Tuff, a rhyolitic welded tuff similar to the Huckleberry Ridge Tuff, with its origin likewise in a caldera in Yellowstone National Park. It has a potassium-argon age of 4.4 million years (Christiansen and Love, 1978). The low hill east of Signal Mountain is composed in part of crushed Paleozoic rocks whose relation to regional structure is unknown. In the foreground south of the highway, Oxbow Lakes are meanders of the Snake River that are ponded as a result of crustal sagging. This is probably why the Snake River now flows east out of Jackson Lake instead of south and southeast as it did earlier in post-glacial times.

| | | |
|---|---|---|
| 3.1 | 0.6 | 24.0 |

Oxbow Lakes—a good place to see variety of water birds.

| | | |
|---|---|---|
| 4.2 | 1.1 | 22.9 |

Turn south on Teton Park Road to Moose. Travelers going to Jackson Lake Lodge and Yellowstone National Park will continue north on Highway 89/287. West of the junction is Willow Flats, a swampy area marginal to Jackson Lake.

| | | |
|---|---|---|
| 4.5 | 0.3 | 22.6 |

Trees to south mark north edge of landslide that flowed northwestward off Signal Mountain, dammed up the Snake River and caused the development of Willow Flats. Later the landslide dam was breached by the river.

*Figure 26. Oblique aerial photograph northwest of the east face of Mount Moran. Vertical relief from bottom of photograph to summit at 12,605 feet is about 3400 feet. Most of the rock is migmatitic biotite gneiss more than 2875 million years old. The light-colored dikes are Mount Owen Quartz Monzonite, about 2500 million years old. The vertical black diabase dike is about 775 million years old. The Flathead Sandstone of Middle Cambrian age, is the light-colored, nearly horizontal gray mound that overlaps the black dike. Falling Ice Glacier is at left, partly covering the black dike; Skillet Glacier is at right. Photograph by Austin S. Post, University of Washington, August 19, 1963.*

| Mileage | | |
|---|---|---|
| Cumulative from Moran Jct. | Increment | Cumulative from Moose |
| 5.4 | 0.9 | 21.7 |

Swampy area to south marks site of artesian well drilled for the old townsite of Moran. It is locally called the "aphrodisiac spring" because moose and deer, for reasons known only to themselves, prefer the water to that in the surrounding area.

5.6 0.2 21.5

Cross Jackson Lake dam. It was started in 1910 and completed in 1916. A history of the dam and human activities was compiled by Markham (1972) and additional data by Diem (1978). The dam raised Jackson Lake 39 feet. The water is used for irrigation in Idaho. The riprap on the earthen part of the dam came from a quarry in the Huckleberry Ridge Tuff southeast of the south end of the dam. The dam was reconstructed in the 1980s.

5.9 0.3 21.2

Small glacial lake to west.

6.1 0.2 21.0

Brinkerhoff Cabin where President Carter, Walter Cronkite, and other dignitaries stay as guests of the Park Service.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Jct. | Increment | Cumulative from Moose |
| 6.3 | 0.2 | 20.8 |

Shore of Jackson Lake to west. The lake was originally nearly 400 feet deep before the dam was built. The lake bottom is asymmetric, with the deepest part near the mountain front. This is thought to reflect the westward tilting of the valley floor as it dropped because of movement along the Teton fault. Highway travels on morainal and outwash debris for the next 10 miles.

| | | |
|---|---|---|
| 7.4 | 1.1 | 19.7 |

Signal Mountain Lodge on west side of road. Optional rest stop.

| | | |
|---|---|---|
| 8.5 | 1.1 | 18.6 |

Road to east goes up Signal Mountain. Round trip takes about an hour and is very worthwhile if time is available. Road is paved all the way but is narrow.

| | | |
|---|---|---|
| 9.1 | 0.6 | 18.0 |

Cross outlet channel number three of Snake River from Jackson Lake through Jackson Lake moraine. This moraine dams the lake and is of late Pinedale age.

| | | |
|---|---|---|
| 9.9 | 0.8 | 17.2 |

Highway skirts southeast edge of Jackson Lake moraine composed of granitic debris from the Teton Range. The moraine is marked by abundant conifers, whereas the flat outwash plains of quartzite gravel support very few trees. The geology for the next 8 miles is on the Jenny Lake Quadrangle (Love, unpublished geologic map; see also Pierce and Good, 1992, and Good and Pierce, 1996).

| | | |
|---|---|---|
| 11.1 | 1.2 | 16.0 |

Approaching timber-covered Burned Ridge moraine of early Pinedale age that crosses the floor of Jackson Hole. We saw the eastern part of it at Stop 3. Note the steep-sided kettles where stagnant ice was buried and then melted out. The lowest swale is outlet channel number two of Snake River from Jackson Lake.

| | | |
|---|---|---|
| 13.4 | 2.3 | 13.7 |

Turn sharply to west on one-way loop road to Jenny Lake. The route crosses the north end of outlet channel number one of Snake River through the Burned Ridge moraine. The paved road to east traverses this channel for 3 miles.

| | | |
|---|---|---|
| 13.9 | 0.5 | 13.2 |

The Cathedral Group, consisting of a cluster of the highest peaks in the Teton Range, is straight ahead for those traveling south. See **Figure 6**, p. 8, for photograph.

| | | |
|---|---|---|
| 15.5 | 1.6 | 11.6 |

Cathedral Group scenic turnout. Due west, near the base of the mountain front is a post-glacial fault scarp 150 feet high, cutting alluvial cones with bright green vegetation on them. The steep east face of the Tetons marks the general trace of the Teton normal fault zone on which nearly 35,000 feet of total displacement is postulated. Much of this movement is thought to have occurred in the last nine million years.

| | | |
|---|---|---|
| 16.3 | 0.8 | 10.8 |

Turn left (south) on paved road to Jenny Lake. Jenny Lake Lodge to east. For the next 2.5 miles the road traverses the Jenny Lake moraine of late Pinedale age, which dams Jenny Lake. Because it consists of granitic debris from the Teton Range, it supports abundant lodgepole pine trees. **Figure 27** shows a panorama of the valley floor and its relation to the Teton front. Jenny Lake is about 225 feet deep.

| | | |
|---|---|---|
| 17.9 | 1.6 | 9.2 |

SUGGESTED STOP 7op (Optional). Overlook at edge of Jenny Lake. The U-shaped canyon to the west is Cascade Canyon, bounded on the south by Mount Teewinot in the foreground, and Mount Owen on the right. The highest summit of the Grand Teton is barely visible behind Mount Teewinot. If parking area is congested, continue 0.6 miles south to next overlook.

| | | |
|---|---|---|
| 18.5 | 0.6 | 8.6 |

Optional overlook stop.

| | | |
|---|---|---|
| 18.9 | 0.4 | 8.2 |

Jenny Lake campground. This area was devastated by a freak hurricane in November, 1973, and almost all the large trees were blown down. Because of the time of year, there were no campers and no injuries.

| | | |
|---|---|---|
| 19.4 | 0.5 | 7.7 |

Reenter main highway—two-way traffic. Nez Perce "Howling Wolf" peak to southwest. From here on south for the next 10 miles, the geology is shown on the Moose Quadrangle (Love, unpublished geologic map).

*Figure 27. Air oblique view of the east face of the Teton Range. The Grand Teton is the highest peak (elevation 13,770 feet). Jenny Lake, 225 feet deep, encircled by a tree-covered terminal moraine, is in the middle ground. Ice that gouged out the lake flowed eastward toward the camera from the U-shaped Cascade Canyon at the right center. Channelways of the Burned Ridge treeless, quartzite gravel outwash plain are visible in the foreground. At the center of the left margin, just above the valley floor, small stair-stepped post-glacial faults cut a treeless alluvial cone. National Park Service photograph by Bryan Harry, 1965.*

| Mileage | | |
|---|---|---|
| Cumulative from Moran Jct. | Increment | Cumulative from Moose |
| 20.0 | 0.6 | 7.1 |

Stair-step postglacial faults to the west cut bright green alluvial cones from torrent gullies on mountain front. See cross section by Love and Montagne (1956, plate 5).

| | | |
|---|---|---|
| 20.4 | 0.4 | 6.7 |

On skyline to east is Sheep Mountain. Timbered Island in foreground is lateral moraine of Bull Lake Glaciation. Highway is on Pinedale outwash. Again, granitic debris supports trees and quartzite gravel does not.

| | | |
|---|---|---|
| 21.4 | 1.0 | 5.7 |

Good view of Grand Teton to west (**Figure 28**). Note Teton glacier and gray, terminal moraine. This is the largest glacier in the Teton Range. The rate of ice movement in the center of the glacier averages about 28 feet per year (Reed, 1967). The rocks are nearly all the Mount Owen Quartz Monzonite which has an age of 2547 ± 3 million years (Zartman and Reed, 1998, in press). **Figure 29** shows a broader view of Middle and Grand Tetons and Mount Owen. Note the black diabase dike on the Middle Teton.

| | | |
|---|---|---|
| 22.3 | 0.9 | 4.8 |

Mountain climbers' camp to west.

| | | |
|---|---|---|
| 22.4 | 0.1 | 4.7 |

Highway is on outwash plain of quartzite gravel. To the

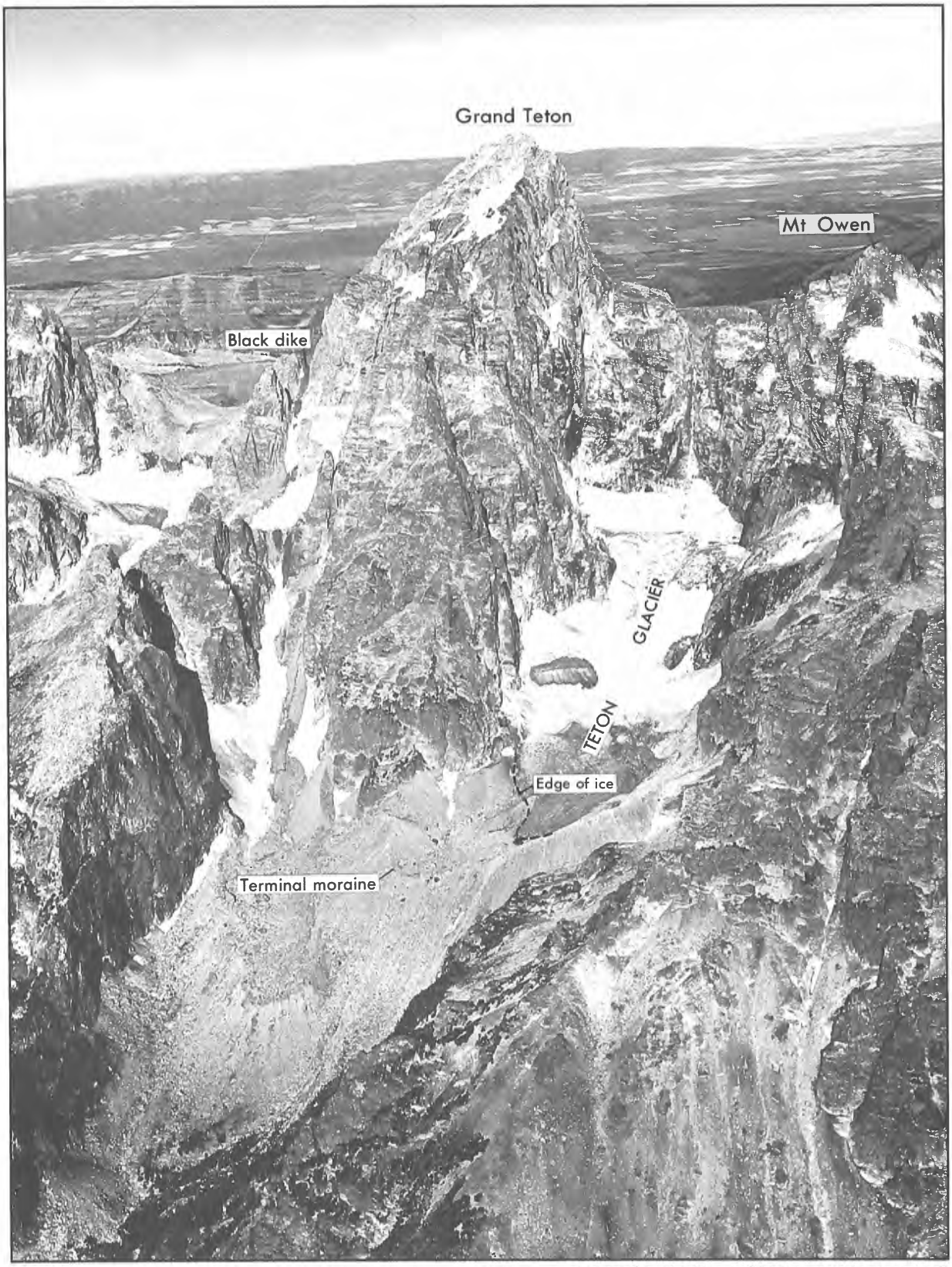



*Figure 28. Air oblique view west showing the Grand Teton and adjacent peaks, the Teton Glacier, and its terminal moraine. Photograph by Austin S. Post, University of Washington, August 19, 1963.*


*Figure 29. Air oblique view west showing Middle Teton cut by a thin black diabase dike on the left, the Grand Teton in the middle, and Mount Owen on the right. Most of the rocks are the Mount Owen Quartz Monzonite, about 2547 million years old. Photograph by H.M. Cowling for the 116th Photo Section, Washington National Guard, 1936.*

southeast in the distance is a bare scar of the Lower Gros Ventre slide. To the right of the slide is Sheep Mountain in the Gros Ventre Range, capped by Madison Limestone. In the near distance is Blacktail Butte. The triangular peak in the far distance is Jackson Peak, composed of Precambrian rocks capped by the Flathead Sandstone.

| Mileage | | |
|---|---|---|
| Cumulative from Moran Jct. | Increment | Cumulative from Moose |
| 24.9 | 2.5 | 2.2 |

Passing Windy Point, which is an uplifted fault block tilted westward, and bounded on the east by a fault that cuts morainal and outwash debris and the overlying loess. This fault scarp continues southward for about 3 miles.

| | | |
|---|---|---|
| 26.5 | 1.6 | 0.6 |

SUGGESTED STOP 8. Moose and Grand Teton National Park Headquarters. Optional stop to obtain park information, view exhibits, and to visit the excellent bookstore.

| | | |
|---|---|---|
| 26.6 | 0.1 | 0.5 |

Bridge over Snake River.

| | | |
|---|---|---|
| 27.1 | 0.5 | 0.0 |

Junction with main highway (U.S. 26/89/191) traversed earlier. From here travelers may retrace the route to Jackson (about 13 miles) or continue north back to Moran Junction (see **Figure 9**).

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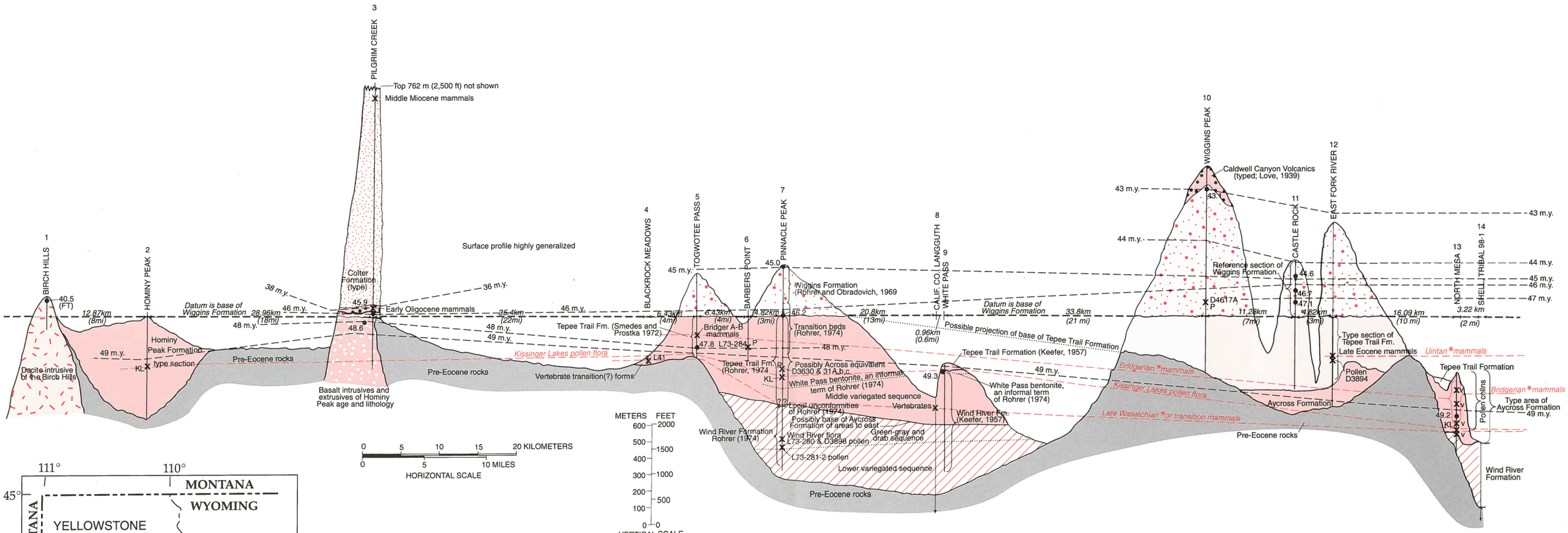
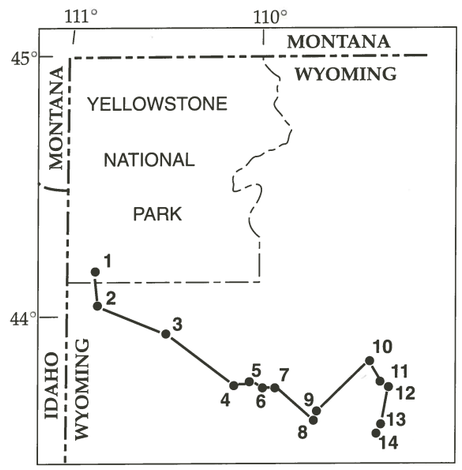
# Field trip notes




INDEX MAP SHOWING LOCATION OF SECTIONS

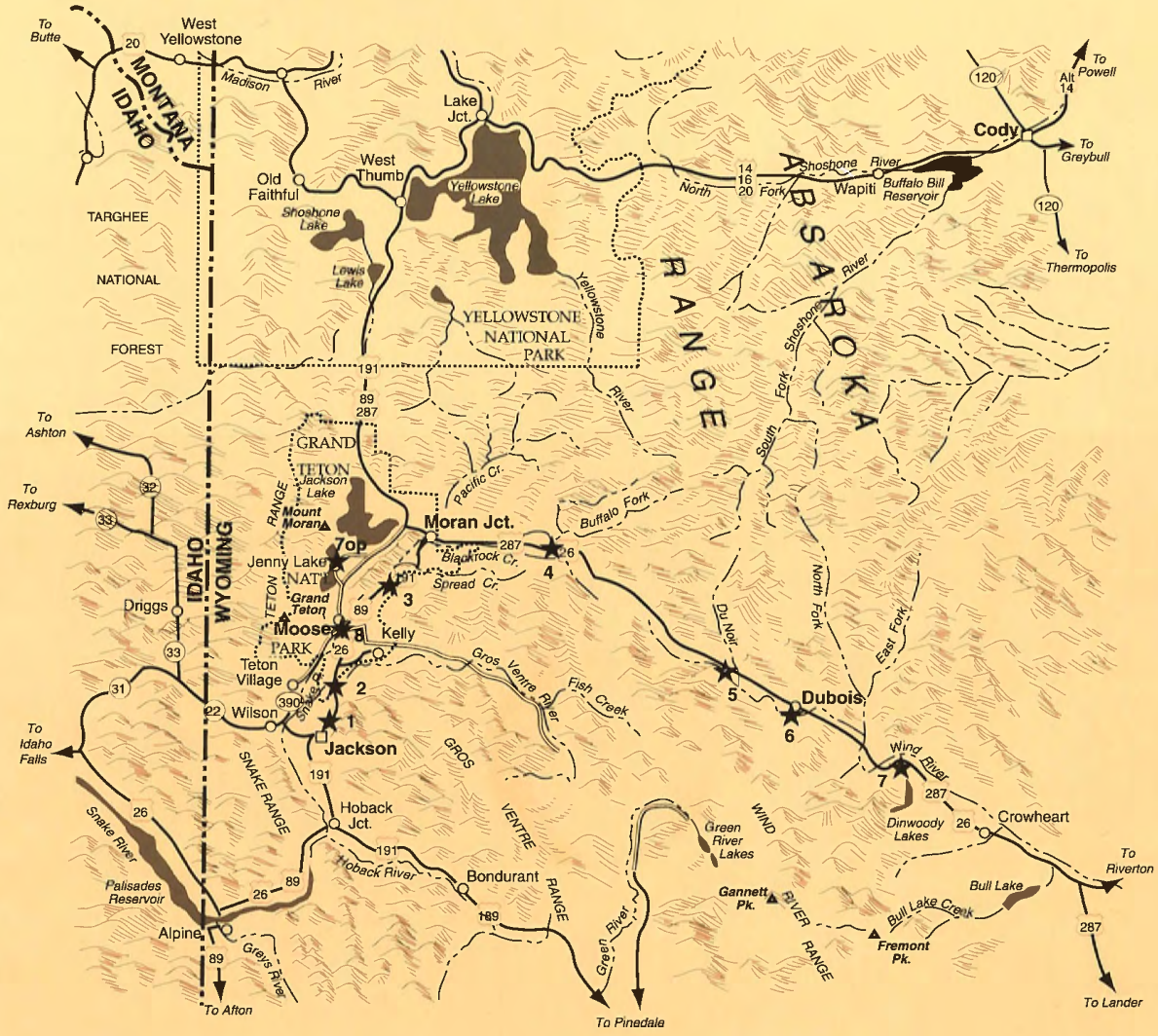
Source data for numbered sections:

(1) L. L. Love (1972);
(2) this report;
(3) J. D. Love (1956b, 1973); Sutton and Black (1972); J. D. Obradovich, written communication, 1975;
(4) J. D. Love (1947), McKenna (1972);
(5) J. D. Love, unpuplished data; McKenna (1972);
(6) J. D. Love, unpublished data;
(7) Rohrer and Obradovich (1969), Rohrer (1974);
(8) J. C. Love, unpublished data;
(9) Keefer (1957), Rohrer (1974), J. D. Love, unpublished data;
(10) J. D. Love (1939) and unpublished data;
(11) J. D. Love (1939) and unpublished data; J. D. Obradovich, *in* Smedes and Prostka (1972);
(12) J. D. Love (1939) and unpublished data;
(13) J. D. Love, unpublished data; J. D. Obradovich, written communication, 1975;
(14) J. D. Love, unpublished data.

EXPLANATION

- 45.9 — Horizon and site of potassium-argon age determination, in millions of years, by J. D. Obradovich
- 40.5 (FT) — Horizon and site of fission track age determination, in millions of years, by L. L. Love
- P — Pollen horizon
- KL — Kisinger Lakes pollen horizon
- D3530 — Pollen collection number and horizon
- V — Fossil mammal horizon
- L41 — Vertebrate fossil quarry site
- * — Provincial land Mammal Age of Wood and others (1941)

*Plate 1. Correlation diagram showing geographic and stratigraphic relations of the Hominy Peak Formation to other Eocene rocks south of the Yellowstone-Absaroka volcanic field and the horizons of radiometric, mammal, and pollen age determinations. Reduced and slightly modified from Love and others (1978), U.S. Geological Survey Professional Paper 932-B, Plate 5.*

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