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STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

William T. Pecora, *Director*

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[Letters designate the separately published chapters]

Geology of the Adam Weiss Peak Quadrangle, Hot Springs and Park Counties, Wyoming

By WILLIS L. ROHRER

CONTRIBUTIONS TO GENERAL GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1241-A

Late Cretaceous and Cenozoic geology with emphasis on the Enos Creek detachment thrust fault

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GEOLOGY OF THE ADAM WEISS PEAK QUADRANGLE HOT SPRINGS AND PARK COUNTIES, WYOMING

By Willis L. Rohrer

ABSTRACT

Exposed formations of the Adam Weiss Peak quadrangle range in age from Late Cretaceous to Recent; unexposed formations penetrated by drilling include rocks as old as Mississippian in age. The exposed Mesozoic formations are conformable and are unconformably overlain by the Paleocene Fort Union Formation. Another unconformity separates the Eocene Willwood Formation and older rocks. Marginal lacustrine deposits, herein assigned to the Tatman Formation of Eocene age, conformably overlie the Willwood Formation and are overlain by tuffaceous sandstone of the Eocene Pitchfork Formation. Thin alluvial deposits of late Pleistocene to Recent age are present along the streams. Pleistocene alluvium was dated by radiocarbon methods but could not be separated lithically from the Recent alluvium.

Geologic structures in the area are broad anticlines and synclines, normal faults, and the Enos Creek detachment fault. Structural relief between the crests of the anticlines and troughs of the synclines is as much as 3,000 feet. The maximum displacement along the normal faults is about 250 feet. The broad anticlines and synclines and a few of the normal faults formed during the late Paleocene. The Pitchfork and, locally, the Tatman form the upper plate of the Enos Creek detachment fault. These formations are deformed into northwest-trending folds that indicate that the upper plate moved northeastward. Movement on the thrust, which occurred during post-Pitchfork and pre-Pleistocene time, may have been several miles.

Structural deformation related to the Laramide orogenic episode resulted in large folds of late Paleocene age. Some of these folds are favorable for the accumulation of oil and gas. Some undrilled localities and formations must be considered potentially valuable for oil and gas.

INTRODUCTION

LOCATION, ACCESSIBILITY, AND RELIEF

The Adam Weiss Peak quadrangle is along the southwest margin of the Bighorn Basin and the southeast flank of the Absaroka Mountains (Shoshone Mountains of Hewett and Lupton, 1917) in Park and Hot Springs Counties of northwestern Wyoming (fig. 1). The

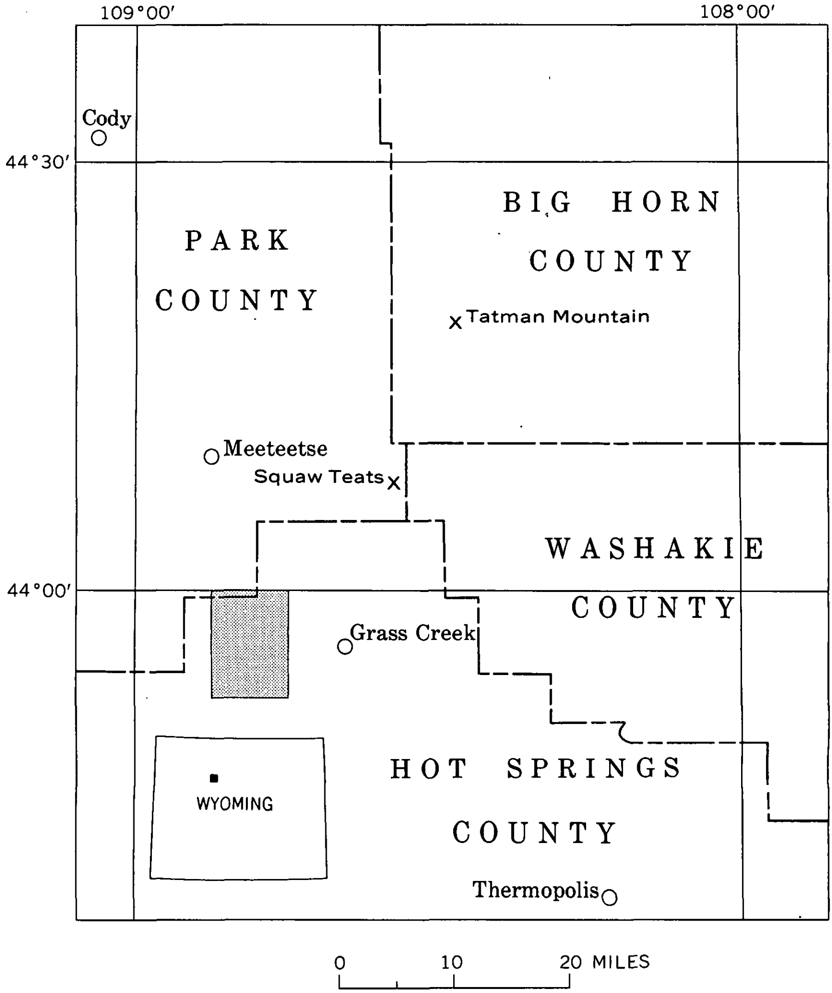

FIGURE 1.—Index map showing location of Adam Weiss Peak quadrangle, Wyoming.

quadrangle is of moderate relief and is for the most part a transition area from arid basin topography to mountainous terrain. This transition is reflected by the flora, as sagebrush and grass of open range give way to shrub and tree juniper, scrub pine, and finally to pine and fir westward into the higher altitudes. The principal drainages are four small perennial streams flowing generally northeast. Access is by way of State Highway 120 connecting Thermopolis to Meeteetse and Cody, Wyo., to the Grass Creek crossing about 25 miles northwest of Thermopolis. From this crossing a surfaced county road goes west to the Enos Creek road. The Grass Creek road is graveled and enters the quadrangle in the SE¼ sec. 29, T. 46 N., R. 99 W., sixth principal meridian. The Enos Creek road is oiled, crosses the divide between Enos and Grass Creeks in a westerly direction, and enters the quadrangle near the E¼ cor. sec. 17, T. 46 N., R. 99 W. Adam Weiss Peak is near the southeast corner of the quadrangle and is a prominent topographic feature, although not the highest in the mapped area. Altitudes in the quadrangle range from about 5,700 feet along Gooseberry Creek, in the northeast corner of the mapped area, to nearly 7,700 feet in the mountainous area north of Bill Dickie Draw, along the west margin of the quadrangle.

FIELDWORK AND ACKNOWLEDGMENTS

This study was undertaken as part of the U.S. Geological Survey's program of classifying mineral lands in the Public Domain. Coal and oil are the two major natural resources in the quadrangle. Mapping was done during the 1960 field season. The geologic map (pl. 1) has been published as U.S. Geological Survey Geologic Quadrangle Map GQ–382 (Rohrer, 1965). The author is indebted to Mr. Max Marcott and his family of Thermopolis, Wyo., for their sincere hospitality and help during the field season.

Oil and coal resource investigations by Hewett (1926) and Hewett and Lupton (1917) between 1911 and 1919 in the adjoining Meeteetse and Grass Creek quadrangles laid the geologic foundation for exploration of these fuels in the southern part of the Bighorn Basin. Hewett (1926) defined the stratigraphic units in these areas, and his nomenclature has been mostly accepted by later workers in the area. For earlier reports, the reader is directed to references cited by Hewett (1926).

More recently, reconnaissance mapping by T. F. Stipp and G. H. Horn resulted in a generalized geologic map of the area that was incorporated into the geologic map of the Bighorn Basin by Andrews, Pierce, and Eargle (1947). Following these investigators, a more detailed study of part of the area was made by E. G. Long.[1]

STRATIGRAPHY

Late Cretaceous, early Tertiary, and Quaternary rocks are exposed in the quadrangle, and unexposed rocks penetrated by drill holes range from the upper part of the Cody Shale of Late Cretaceous age to the Madison Limestone of Mississippian age (pl. 2). Thicknesses of exposed strata shown by plate 2 were described from outcrops in the quadrangle and measured by tape, hand level, and Brunton

[1] Long, E. G., 1957, Geology of the Enos Creek area, Bighorn Basin, Hot Springs County, Wyoming: Wyoming Univ., unpub. master's thesis.

compass. Descriptions of the unexposed formations were derived from a lithologic log of the well in the Enos Creek field in the SE¼SW¼NW¼ sec. 25, T. 46 N., R. 100 W., sixth principal meridian. The lithologic well log was furnished, and its data published by permission of the Marathon Oil Co.

UNEXPOSED ROCKS

PALEOZOIC ERA

MADISON LIMESTONE

The upper 243 feet of the Mississippian Madison Limestone consists of the oldest rocks penetrated by drill in the map area. The total thickness of the Madison probably does not exceed 500 feet in the quadrangle because it is only 465 feet thick in the western part of the nearby Grass Creek oil field. The upper 189 feet of the formation consists of greenish- to brownish-gray oolitic and cherty limestone; the remainder is interbedded gray limestone, brown dolomite, and dolomitic limestone (Denson and Morrissey, 1952, p. 38). This part of the Madison in the quadrangle probably correlates with the lower part of the Madison (Lodgepole Limestone) of Montana. The upper part of the Madison of Montana (Mission Canyon Limestone) seemingly is not present. The Madison is unconformably overlain by the Darwin Sandstone Member of the Amsden Formation (Keefer, 1957, p. 168; Thomas, 1948, p. 88).

AMSDEN FORMATION

The Mississippian and Pennsylvanian Amsden Formation is 290 feet thick and consists mainly of light-gray and gray limestone and dolomitic limestone, varicolored shale, sandstone, and some anhydrite. The basal sandstone, 46 feet thick, is known as the Darwin Sandstone Member in the Wind River and southern Bighorn Basins. A 10-foot anhydrite bed and some red and purple shale occur near the middle of the formation. The contact of the Amsden and overlying Tensleep Sandstone is conformable, and apparently transitional, and is placed at the top of the uppermost green or red shale beds.

TENSLEEP SANDSTONE

The Pennsylvanian Tensleep Sandstone is 225 feet thick and consists of fine-grained white to tan crossbedded to massive sandstone that contains interbedded limestone in the lower 70 feet. The contact with the overlying Park City Formation may be unconformable (Agatston, 1952, p. 44). The contact is placed at the top of the sandstone overlain by sandy carbonate beds.

PARK CITY FORMATION

The Permian Park City Formation is 238 feet thick in the quadrangle and may be divided as follows: A lower unit of brown cherty dolomite with a basal sandy limestone, 45 feet thick; a middle unit of gray and brown cherty limestone, 173 feet thick; and an upper unit of brown dolomite, 20 feet thick. The three units described above are probably equivalents of the Franson Member of the Park City Formation, the Tosi Chert Member of the Phosphoria Formation, and the Ervay Carbonate Rock Member of the Park City Formation, respectively (McKelvey and others, 1959). The lower unit is commonly considered to be the top of the underlying Tensleep Sandstone. Lithologic variations, however, are so diverse in the Bighorn Basin that no one section can be considered typical (Frielinghausen, 1952). This formation is usually recorded in the Bighorn Basin as the "Embar" or "Phosphoria" by many geologists (Tourtelot, 1952).

The contact of the Park City and the overlying Dinwoody Formation is unconformable (Thomas, 1948, p. 92) and is placed at the top of the dolomite below green shales of the Dinwoody Formation.

MESOZOIC ERA

DINWOODY FORMATION

The Dinwoody Formation of Early Triassic age is 105 feet thick and consists of green calcareous and gypsiferous shale that contains streaks of brown dolomite and white sandstone in the upper 20 feet. The dolomite and green shale in the upper part of the Dinwoody Formation is overlain conformably by red shale in the lower part of the Chugwater Formation.

CHUGWATER FORMATION

The Triassic Chugwater Formation is 1,165 feet thick and consists of very fine grained red sandstone and greenish-gray and red shale that contain thin beds of light-brown limestone in the lower 200 feet. A sandstone bed, 108 feet thick, occurs at the top of the Chugwater Formation. A Triassic age has been tentatively given to this sandstone, although it may be correlative with the Nugget Sandstone of Jurassic age (Love, 1948, p. 100–101). The Triassic rocks are overlain unconformably by the Gypsum Spring Formation of Middle Jurassic age.

GYPSUM SPRING FORMATION

The Gypsum Spring Formation of Middle Jurassic age is 87 feet thick and consists of white to light-grayish-brown anhydrite interbedded with grayish-brown dolomite. The formation contains some red shale at the top and the base. The contact seems to be transitional with the overlying Sundance; however, according to Imlay (1956, p. 579–580), this contact is unconformable.

SUNDANCE FORMATION

The Sundance Formation of Late Jurassic age is 435 feet thick. The lower 295 feet is mainly gray-green and brown shale and minor thin beds of brown oolitic limestone and glauconitic sandstone. Some thin white anhydrite beds are in the basal 50 feet. The remaining upper 140 feet of the formation consists of fine-grained glauconitic white to gray-green sandstone and green and brown shale. The upper contact, which seems conformable, is distinguished by the change from glauconitic strata of the Sundance Formation to nonglauconitic beds of the Morrison Formation.

MORRISON FORMATION

The Morrison Formation, 185 feet thick, is Late Jurassic in age. The formation consists of variegated shale with thin limestone interbeds and white to brown sandstone. The upper contact is placed where variegated shale is overlain by a conglomerate in the Cloverly Formation, apparently marking an unconformity.

CLOVERLY FORMATION

The Lower Cretaceous Cloverly Formation is 365 feet thick and is subdivided as follows: A lower unit of fine- to medium-grained white sandstone with a basal coarse-grained sandstone and conglomerate, 65 feet thick; a middle unit of variegated shale or claystone and thin beds of sandy shale, 120 feet thick; and an upper unit of fine- to medium-grained gray and reddish-brown sandstone and scattered thin beds of shale, 180 feet thick. These units are commonly correlated with the Inyan Kara Group of the Black Hills region. The reddish-brown sandstone in the upper unit is frequently referred to as the rusty beds.

The upper contact is marked by the change from gray and rusty sandstone in the Cloverly to black shale in the Mowry and Thermopolis Shales.

MOWRY AND THERMOPOLIS SHALES

The undifferentiated Mowry and Thermopolis Shales of Early Cretaceous age total 775 feet thick and can be divided into three members. The lower member, 140 feet thick, is a black shale of the Thermopolis Formation. This shale is overlain by the 40-foot Muddy Sandstone Member of the Thermopolis Formation. The Muddy is a gray medium- to coarse-grained thin-bedded fucoidal sandstone. The upper member, 595 feet thick, consists of dark-gray to black shale with thin interbeds of gray sandstone, sandy shale, bentonite, and white bentonitic shale. This member forms the upper part of the Thermopolis Shale and the Mowry Formation. The top of an anhydrite bed, 7 feet thick, marks the upper contact of the Mowry and Thermopolis Shales with the Frontier Sandstone, as well as the boundary between the Lower and Upper Cretaceous.

FRONTIER FORMATION

The Upper Cretaceous Frontier Formation is 550 feet thick and is mainly fine- to medium-grained gray salt-and-pepper sandstone and shaly sandstone interbedded with dark-gray sandy shale. A thin but distinctive zone of white chert occurs 70 feet above the base of the formation, and a marker bed of white waxy shale occurs 360 feet above the base. Commonly, a massive sandstone is at the base and another is at the top of the formation. Where these massive sandstones occur, the name Peay Sandstone Member (of Hintze, 1915, p. 21) is applied to the basal one and Torchlight Sandstone Member (of Hintze, 1915, p. 23) to the upper.

The upper contact of the formation is marked by the change from sandstone of the Frontier Formation to dark-gray shale of the Cody.

CODY SHALE

The upper Cretaceous Cody Shale, the oldest formation exposed in the Adam Weiss Peak quadrangle, ranges in total thickness from nearly 2,400 to 2,900 feet, as shown by logs of drill holes and measured surface sections (pl. 2).

The unexposed Cody Shale is 2,465 feet thick in the abandoned well in the SE¼SW¼NW¼ sec. 25, T. 46 N., R. 100 W. The lower half of the formation is dominantly gray to dark-gray shale with some sandy shale, glauconitic sandstone, and thin bentonite beds, whereas the upper half is mainly interbedded gray sandy shale and sandstone.

EXPOSED ROCKS

MESOZOIC ERA

CODY SHALE

Only the uppermost part of the Cody Shale is exposed in the quadrangle, and the outcrops occur where erosion has removed overlying strata along the crests of anticlines. The upper 600 feet of the Cody is exposed on the Renner Draw-Gooseberry Creek divide in the Gooseberry anticline and about 320 feet crops out in the Enos Creek anticline (fig. 2). Still less of the Cody is exposed at the south boundary of the map in the SE¼ sec. 10, T. 45 N., R. 100 W.

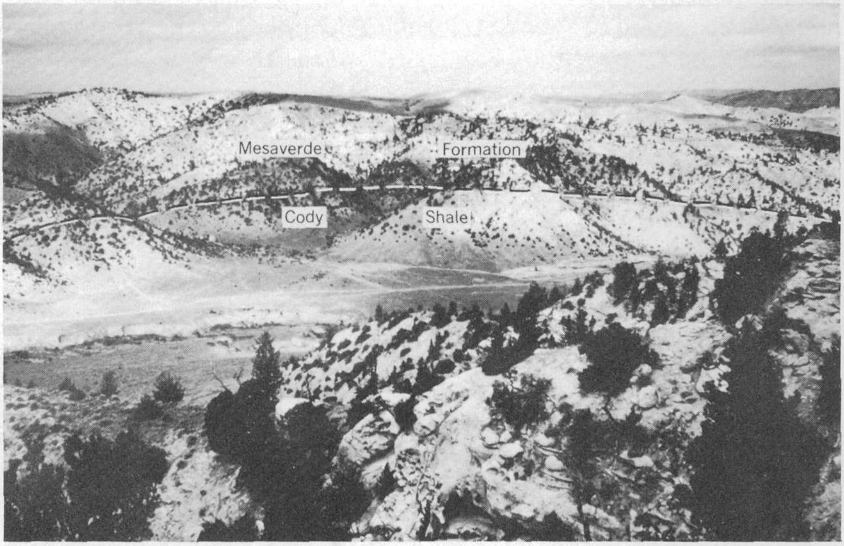

FIGURE 2.—View northwest of Enos Creek oil and gas field before abandonment. Ledges in foreground are Mesaverde Formation.

The exposed Cody is mainly light-gray thinly laminated limy sandstone and subordinate gray shale that locally grade laterally into thin marly zones. The upper 200 feet of the sandstone, however, is thick bedded and resistant and forms cliffs. The lower part is thin bedded, shaly, and forms slopes. The contact between the Cody and the overlying Mesaverde is gradational. The contact was arbitrarily picked at the base of the lowest massive sandstone below the lowest coal zone in the Mesaverde.

Plant debris, baculite fragments, and fish scales occur in the thinly laminated sandstone and shales. Ripple marks and "worm trails" mark bedding surfaces. These features seem to indicate that the Cody was deposited in a shallow marine environment.

The range in thickness of the Cody in the map area is due to intraformational thickening or thinning, probably resulting from local subaerial erosion coupled with nondeposition. Similar intraformational irregularities in thickness have been noted in other marine Upper Cretaceous sections by Cobban and others (1959). Weimer (1960) described major transgressive and regressive movements of the Cretaceous sea during epeirogenesis and ascribes gaps in the marine sequence to nondeposition or retarded deposition.

MESAVERDE FORMATION

The Upper Cretaceous Mesaverde Formation is about 1,880 feet thick in the central part of the quadrangle. A computation based upon projection of strata attitudes along Little Grass Creek, off the south edge of the map, gives a thickness of 1,740 feet. These thicknesses are about 300–400 feet greater than the maximum measurement made by Hewett (1926, p. 19), who indicated that the Mesaverde ranges in thickness from 995 to 1,450 feet. Hewett found no pattern to the thickening and attributed the thicknesses of less than 1,450 feet to uncertainty in placement of the upper contact. Comparison of measurements by Hewett and the writer indicates irregular thinning north and east from the map area. In support of this thinning, Horn (1963) shows that the formation does thin eastward and is in part equivalent to the upper part of the Cody in the area northeast of Thermopolis.

The Mesaverde Formation crops out extensively (pl. 1) and is composed of massive sandstones and minor interbedded shale, siltstone, and coal. Most of the massive sandstones are lenticular and generally cannot be traced more than a few hundred yards along the outcrop. Some sandstones have torrential crossbedding; others are thin to thick bedded. Some sandstones are thinly laminated, whereas others have few or no laminae.

The formation can be separated into two members of nearly equal thickness. The lower member contains coal and is about 920 feet thick. It consists of a basal massive sandstone, about 145 feet thick, which locally can be subdivided into three units: a massive nonlaminated lower unit, a thin- to thick-bedded intermediate unit containing large sandstone concretions in the lower part, and a resistant massive upper unit. The main coal-bearing zone, about 75 feet thick, overlies the basal sandstone and is composed mainly of thin-bedded sandstone and shale. The coal is lenticular and commonly grades laterally to shale. The main coal bed, generally less than 8 feet thick, is in the lower part of this zone. The remainder of the lower member is resistant sandstone that contains some thin shale interbeds and a few thin coal beds.

The contact of the lower and upper members is marked by a light-gray to gray coarse-grained bentonitic quartzose siltstone, 3–5 feet thick, that occurs near the middle of the Mesaverde Formation about 920 feet above the base. The siltstone is less resistant than the underlying and overlying sandstones and erodes to a stratal groove with a knobby surface. This bed is generally poorly exposed.

The upper member consists mainly of massive sandstone, locally flaggy, that contains large limy sandstone concretions in the upper part. Two dark-brownish-black carbonaceous shale beds are present locally, one about 340 feet and the other about 280 feet below the top of the formation, but no coal was found in the upper member. A lens of pale-green waxy bentonite, 6.5 feet thick, is present a short distance west of the NE. cor. sec. 2, T. 46 N., R. 100 W. The stratigraphic position is uncertain, but it is about 300–350 feet below the top of the formation. An X-ray diffractogram of the bentonite shows it to be about 70 percent montmorillonite and 30 percent quartz. A measured section of the Mesaverde Formation is given as follows:

Section of Mesaverde Formation measured from the Enos Creek field to near center sec. 18, T. 46 N., R. 99 W.

	Feet
Meeteetse Formation.	
Mesaverde Formation:	
Upper member:	
Sandstone, light-gray, fine-grained, massive, concretionary	89
Sandstone, light-gray, fine- to medium-grained, massive, locally very resistant; contains large limy sandstone concretions that weather dark brown	190
Shale, dark-brownish-black, with thin sandstone interbeds	23
Sandstone, very light gray (buff at top), fine- to medium-grained, massive: forms slope	42
Shale, black, carbonaceous	4
Sandstone, light- to light-buff-gray, fine- to medium-grained, massive; concretions in middle	31
Sandstone, light-gray to rusty-brown, medium-grained; forms slope	14
Sandstone, light- to light-buff-gray (rusty-brown at top), medium-grained; contains thin lenses of coarse-grained sandstone and clay pebble conglomerate; upper part massive, lower part forms slope	55
Sandstone, light-gray to tan, fine- to medium-grained; forms slope except where rusty colored; locally massive and concretionary	30
Sandstone, very light gray to light-buff-gray and buff, fine- to medium-grained, massive- to thin-bedded; generally forms ledges	217
Sandstone, very light gray to light-buff-gray, fine- to medium-grained, massive; forms ledges; contains thin lenses of claystone pebbles	262
Thickness of upper member	957
Lower member:	
Siltstone, light-gray to gray, bentonitic, and quartzose	4
Sandstone, light-gray to buff, fine- to medium-grained, thin- to thick-bedded; forms ledges and slopes	176
Siltstone, light-gray, and light-gray medium-grained sandstone; mostly obscured	8
Sandstone, light- to light-buff-gray and tan, fine- to medium-grained, massive; forms persistent ledge; contains carbonaceous siltstone about 18 ft above base	47

Section of Mesaverde Formation measured from the Enos Creek field to near center sec. 18, T. 46 N., R. 99 W.—Continued

	Feet
Mesaverde Formation—Continued	
Lower member—Continued	
Sandstone, light- to buff-gray, fine- to medium-grained, flaggy; generally forms slope	68
Claystone, light-gray	7
Sandstone, light-buff- to buff-gray, medium-grained, thin-bedded, flaggy	9
Claystone, light-gray; some thin light-gray medium-grained sandstone; mostly obscured	20
Sandstone, light-gray, medium-grained, massive, crossbedded; forms intermittent ledge	21
Sandstone, light- to light-buff-gray, fine- to medium-grained, thin- to thick-bedded and massive; forms cliffs; concretionary in upper part; some clayey intervals	57
Sandstone, light-gray to buff, fine- to medium-grained, thin-bedded, and interbedded gray shale; mostly obscured	142
Sandstone, light-gray to light-buff, fine-grained, massive; forms cliffs	23
Sandstone, light- to light-buff-gray, fine- to medium-grained; thin-bedded and flaggy in upper third; lower part massive; ironstone nodules near middle	125
Shale, gray, and fine- to medium-grained sandstone; thin coal (12 in.) near top	13
Sandstone, light- to light-buff-gray, fine-grained, thin- to thick-bedded	15
Sandstone, light-buff to buff-brown, fine-grained; gray shale; coal (20 in.) near top and base	20
Shale, gray, carbonaceous, with streak coal (8 in.) at base; thin rusty-brown fine-grained sandstone ledge at top	27
Sandstone, light- to light-buff-gray, fine- to medium-grained, massive; forms ledge	30
Sandstone, light-buff-gray, fine- to medium-grained, thin- to thick-bedded; contains concretions near base which form curved rectangular blocks due to spalling	46
Sandstone, light- to light-buff-gray, fine- to medium-grained, massive; rusty brown at top	69
Thickness of lower member	927
Total thickness Mesaverde Formation	1,884

Cody Shale.

The Mesaverde Formation is overlain conformably by the Meeteetse Formation, and the contact is placed at the change from resistant massive sandstone of the Mesaverde to nonresistant bentonite, claystone, shale, siltstone, or clayey sandstone of the Meeteetse.

On the basis of plant remains and marine invertebrate fossils from the roof rock over the lowest coal bed, the Mesaverde is of Montana age

(Hewett, 1926, p. 20). The writer found a palm frond and clam molds. These fossils seem to indicate that the Mesaverde was deposited in a swampy marginal marine environment.

MEETEETSE FORMATION

The Upper Cretaceous Meeteetse Formation ranges in thickness from about 650 to 710 feet in the quadrangle. In the E½ sec. 30, T. 46 N., R. 99 W., it is about 650 feet thick. Two miles north, the formation is about 675 feet thick; along Left Hand Creek on the south flank of the Mausoleum syncline, it is about 680 feet thick; and in sec. 10, T. 46 N., R. 100 W., the Meeteetse is 710 feet thick. These thicknesses confirm the northwestward thickening that was reported by Hewett (1926, p. 23).

The Meeteetse Formation crops out around the flanks of the four major synclines shown on plate 1. Meeteetse strata are poorly indurated and easily eroded. The formation is poorly exposed except in its upper part just below cliffs and steep slopes formed by the overlying formation (fig. 3).

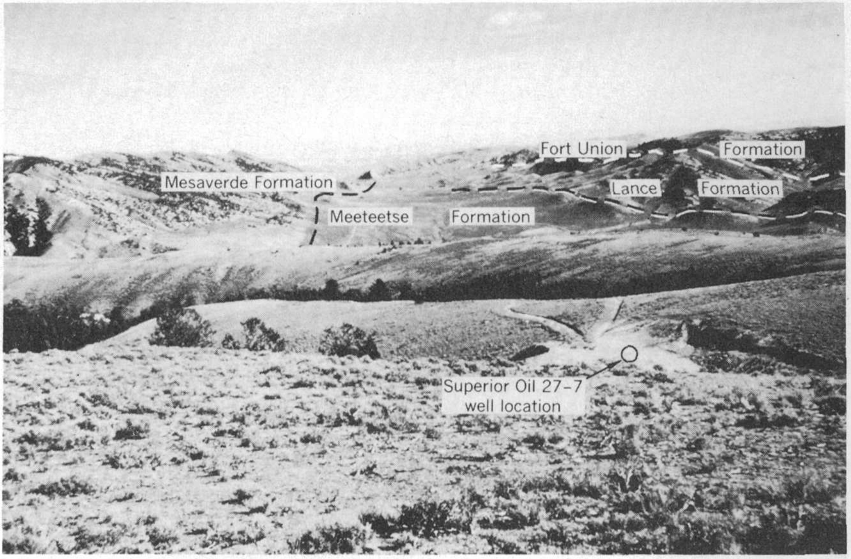

FIGURE 3.—View east through broad grassy valley in Meeteetse Formation on north flank of Grass Creek syncline and south flank of Walker dome. Rounded ridges in foreground are Mesaverde Formation.

The Meeteetse consists of poorly indurated clayey to silty sandstone interbedded with clayey to sandy siltstone, claystone, shale, bentonite, and thin coal beds. The sandstone, which is dominant in the lower part of the Meeteetse, generally is light gray to gray buff. Thin zones of limestone concretions occur in sandstones 215–350 feet above the base of the formation. The siltstone weathers light gray to light buff gray, whereas the claystone weathers gray to dark gray. These beds commonly grade from one lithic type to another. A representative measured section of the Meeteetse Formation is given as follows:

Section of Meeteetse Formation in the E½ sec. 30, T. 46 N., R. 99 W.

	Feet
Lance Formation.	
Meeteetse Formation:	
Sandstone, fine-grained; some light-gray to buff siltstone; thin coal (8 in.) at top	8.5
Shale and siltstone, gray; coal (15 in.) in lower part	5.0
Sandstone, fine-grained, and interbedded siltstone, light-gray (weathers rusty brown)	12.5
Claystone, gray; contains coal bed (17 in.) in middle	5.5
Claystone, gray; small ledge of sandstone at top	5.5
Sandstone, light-gray, fine-grained; forms ledge	5.5
Claystone, gray; contains coal bed (22 in.) in middle	5.0
Sandstone, light-gray to light-buff, fine-grained, thin- to thick-bedded	23.0
Claystone, gray; carbonaceous shale at top	13.0
Sandstone, light-gray, fine-grained, silty, massive; forms slope	31.0
Claystone, gray; contains interbeds of carbonaceous shale	23.5
Siltstone and fine-grained sandstone, light- to light-buff-gray, interbedded	19.0
Claystone, gray; carbonaceous shale at base	13.0
Sandstone, light-buff-gray, fine-grained, massive, lenticular	23.5
Shale, siltstone, and fine-grained sandstone, gray to light-buff-gray	11.5
Sandstone, light- to light-buff-gray, fine-grained, silty	11.0
Shale, grayish-black	6.0
Coal with interbedded gray clay	5.5
Sandstone, light-gray, fine-grained, concretionary; black carbonaceous shale; thin coal (12 in.) in middle	7.5
Shale, siltstone, and fine-grained sandstone, light-gray and gray	15.5
Sandstone, light- to light-buff-gray, fine-grained, silty, thin-bedded	11.0
Claystone and sandy siltstone, crossbedded; few ironstones; upper part silty sandstone	45.0
Claystone, gray; coal at top (15 in.) and base (16 in.)	9.0
Sandstone, light-gray to very light gray, fine-grained, silty, concretionary	50.0
Siltstone, light- to olive-gray, clayey, sandy; locally concretionary; capped by carbonaceous shale	16.0
Sandstone, light-gray to light-buff, fine-grained, silty, concretionary	7.0
Siltstone, light-gray, sandy; carbonaceous shale at top	8.0
Claystone, gray, silty, sandy; some ironstone; base bentonitic; thin coal (5 in.) at top	17.0
Shale, brownish-black, carbonaceous; siltstone, light-gray, sandy; claystone, gray; thin seams of coal (as much as 5 in.)	13.5
Sandstone, light-gray, very fine grained, silty, concretionary	25.5

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Section of Meeteetse Formation in the E½ sec. 30, T. 46 N., R. 99 W.—Continued

Meeteetse Formation—Continued	*Feet*
Claystone, gray; some carbonaceous shale and coal (14 in.)	15.0
Sandstone, light-gray, very fine grained, silty	22.0
Claystone, gray, silty; small sandstone ledge at top	9.0
Sandstone, gray, very silty; grades upward into sandy siltstone and silty claystone; seam of coal (3 in.) at top	22.5
Claystone, gray, mostly obscured; thin black shale in middle and coal (13 in.) at top	73.0
Sandstone, light-gray, fine-grained; forms small ledges; some interbedded siltstone; ripple marks	34.0
Shale, gray, carbonaceous; some interbedded sandstone; coal (20 in.) near top	18.5
Sandstone, light-gray, fine-grained; shale, gray, at base	6.0
Total thickness Meeteetse Formation	652.5
Mesaverde Formation.	

Most of the beds in the Meeteetse are lenticular and commonly pinch out within a few hundred feet. Locations of paleostream channels are indicated by lenses of well-sorted sandstone. Sandstone beds grade laterally into siltstone and claystone, and carbonaceous shale grades laterally into claystone or coal. The formation was deposited in swampy environments or by streams.

Coal beds are scattered throughout the formation; 16 coal beds are exposed in the Meeteetse in the E½ sec. 30, T. 46 N., R. 99 W., on the southwest flank of the Grass Creek syncline. Most of these beds are less than 14 inches thick, but a few locally thicken to as much as 30 inches.

The Meeteetse Formation is overlain by the Lance Formation. The contact of the two formations is sharp and marked by slope-forming Meeteetse strata overlain by a resistant massive sandstone in the Lance Formation. Locally, a thin coal bed forms the uppermost bed in the Meeteetse. In most places the contact seems conformable, but where present, the uppermost coal is weathered, and the increase in thickness of the Meeteetse Formation northwestward may indicate truncation.

Plant fragments are locally abundant, and about 20 fossil plant genera from the Meeteetse Formation were reported by Hewett (1926, p. 23, 24). According to Hewett, these fossils indicate that the Meeteetse is of Montana age and is correlative with the Judith River Formation of Montana.

LANCE FORMATION

The Lance Formation, the uppermost unit of the Cretaceous System, crops out along the four major synclines in the quadrangle. At Grass Creek syncline, the Lance is 760 feet thick; at Mausoleum syncline, about 740 feet thick; at Twin Buttes syncline, about 630 feet thick; and at Left Hand syncline, about 800 feet thick. The thicker section of Lance at Left Hand syncline may be due to folding.

The Lance Formation is here informally subdivided into two members. The lower member is mainly massive sandstone, about 550 feet thick; the upper member is interbedded claystone, siltstone, and sandstone, about 210 feet thick. The lower member, in the N½ sec. 29, T. 46 N., R. 99 W., consists of a basal massive cliff-forming sandstone, 217 feet thick; a series of thin- to thick-bedded and massive sandstones that form cliffs separated by short steep slopes, 207 feet thick; a gray claystone bed, 11 feet thick; and another massive cliff-forming sandstone, 112 feet thick. Small lenses of claystone pebbles occur in the massive sandstones, and small grayish-black chert pebbles occur locally near the base of the topmost massive sandstone.

The upper member forms a slope broken by ledges of relatively resistant sandstone. Gray claystone and siltstone are interbedded with thin- to thick-bedded sandstone that weathers to platy fragments which litter the outcrop. The uppermost 70 feet of this member in sec. 29, T. 46 N., R. 99 W., contains a few beds of maroon siltstone and claystone.

According to Hewett (1926, p. 68), an unconformity marks the contact of the Lance Formation with the overlying strata. A measured section of the Lance Formation is given as follows:

Section of the Lance Formation in the N½ sec. 29, T. 46 N., R. 99 W.

	Feet
Fort Union Formation.	
Unconformity.	
Lance Formation:	
Upper member:	
Siltstone, some fine- to medium-grained sandstone, and claystone; alternating beds of gray and maroon; rusty yellow near top	72.5
Claystone, gray, and fine- to medium-grained sandstone, light-gray, interbedded; forms small ledges	52.0
Sandstone, light-buff-gray to brown, fine-grained. thick-bedded; forms ledge	9.5
Claystone, gray, and some interbedded fine- to medium-grained sandstone; mostly obscured	50.0
Sandstone, light-buff-gray, fine-grained, thick-bedded; forms small scattered ledges	11.5
Claystone, gray; mostly obscured	17.0
Thickness of upper member	212.5

Section of the Lance Formation in the N½ sec. 29, T. 46 N., R. 99 W.—Continued

Lance Formation—Continued	
Lower member:	*Feet*
Sandstone, light-gray, fine- to medium-grained, massive; contains thin lenses of clay pebble and chert pebble conglomerate; forms cliff	112.5
Claystone, gray; forms slope; mostly obscured	11.0
Sandstone, light-buff-gray to light-buff, fine- to medium-grained, massive; forms cliffs	33.5
Covered; probably claystone	11.5
Sandstone, light-buff-gray and gray, fine-grained, massive; forms cliff; basal few feet weathers to form short slope; contains some thin claystone conglomerate lenses	63.0
Sandstone, light- to light-buff-gray, thin- to thick-bedded; upper part weathers to angular blocks; mostly obscured	64.0
Sandstone, light-gray, fine-grained, thin- to thick-bedded; silty interbeds; generally forms slope	35.0
Sandstone, light- to light-buff-gray, fine-grained, massive; forms cliff; locally contains thin lenses of claystone pebble conglomerate	217.0
Thickness of lower member	547.5
Total thickness Lance Formation	760.0
Meeteetse Formation.	

No fossils were found in the Lance Formation in the Adam Weiss Peak area. The two members described, however, correlate with sections described by Hewett (1926, p. 27, fig. 4), who reported that the Lance contained fossils indicative of Late Cretaceous age. The invertebrate and vertebrate fossils indicate that the formation was deposited in a continental environment (Hewett, 1926, p. 27, 28).

CENOZOIC ERA

FORT UNION FORMATION

The Paleocene Fort Union Formation (Polecat Bench Formation of Jepsen, 1940, and Jepsen and Van Houten, 1947) is more than 600 feet thick along the axis of the Grass Creek syncline. In the Left Hand syncline only the basal sandstone and conglomerate, about 90 feet thick, are present. The formation is thicker beyond the map area along these synclinal axes.

The basal unit of the Fort Union Formation consists of cliff-forming sandstone and conglomerate about 95 feet thick. This unit may be subdivided as follows: A lower massive fine- to coarse-grained light-gray sandstone that contains thin quartzite pebble conglomerate lenses; a middle quartzite conglomerate that contains some granitic pebbles and chunks of gray claystone in a coarse-grained sandstone matrix; and an upper massive medium-grained light-gray sandstone that contains conglomerate lenses in the lower part. More than 90 percent of the conglomerate in the basal unit is formed of quartzite pebbles and cobbles.

Above the basal unit the formation consists of alternating claystone, sandstone, and siltstone beds, and minor amounts of coal. The claystone is generally gray but some is maroon. The sandstone ranges from very fine to coarse grained, is light gray, commonly irregularly bedded, and ledge forming. The more massive sandstone units locally contain limy concretions. A sandstone that contains thin irregular layers of quartzite pebble conglomerate is present about 490 feet above the base of the formation. The siltstone is gray and usually sandy. Thin coal beds or carbonaceous shales are locally present in the lower 500 feet of the Fort Union. The principal coal beds, however, are 500 and 630 feet above the formation base and are 4 feet and 22 feet thick, respectively (Hewett, 1926, pl. 14). The 4-foot coal was not observed; it may be represented by a clinker or carbonaceous shale interval.

The original thickness of the Fort Union Formation in the Adam Weiss Peak quadrangle is unknown, owing to erosion before deposition of the overlying Eocene Willwood Formation. In the central Bighorn Basin, where no unconformity is evident at the top, the Fort Union is 3,500 feet thick (Jepsen and Van Houten, 1947, p. 144). The greater thickness of the Fort Union strata in the central Bighorn Basin may be due to an accumulation of reworked Fort Union sediments which were eroded from the marginal basin areas where uplift occurred. Hewett (1926, p. 68) states, "some of the basinward anticlines of the border belt were formed appreciably later than those nearer the mountains * * *." More recently, Jepsen and Van Houten (1947, p. 144), with regard to the basal part of the Fort Union, state, "Peripheral deformation of the basin was progressive during the deposition of the Polecat Bench sediments * * *." The peripheral deformation did not result in pronounced diastems in the Fort Union Formation in the quadrangle.

No fossils were collected from the Fort Union Formation in the Adam Weiss Peak quadrangle; however, more than 40 genera of plant fossils from the Fort Union of adjacent areas were identified by F. H. Knowlton (Hewett, 1926, p. 34, 35). These fossils were collected from just above the basal sandstone and conglomerate unit to 1,200 feet above the base. Most of the fossils indicated a Paleocene age for the Fort Union. The genus *Salvinia*, which has been considered to be of Eocene age by some investigators, was among these collections. However, according to H. D. MacGinitie (written commun., Jan. 31, 1964), "*Salvinia* is a highly specialized water fern and obviously has a very ancient lineage."

WILLWOOD FORMATION

The Willwood Formation of early Eocene age is 340 feet thick in the N½NE¼ sec. 28, T. 46 N., R. 100 W. In the Grass Creek and Oregon Basin quadrangles, Hewett (1926, p. 44, 46) found thicknesses of the Wasatch (Willwood and Tatman Formations of this report) ranging from 500 to 1,200 feet. Pierce and Andrews (1941, p. 136) estimated the Wasatch (Willwood of this report) in the region south of Cody, Wyo., to be about 1,700 feet thick and indicated that most of the Wasatch sediments were either removed from that part of the Bighorn Basin before deposition of the overlying formation or that the thinner section resulted from nondeposition of the lower strata. The latter conclusion is discussed by Hewett (1926, p. 61–62, 68).

The Willwood consists of sandstone and conglomerate interbedded with minor amounts of gray and maroon claystone and siltstone. Locally, the sandstone and conglomerate are arkosic. The basal part of the formation varies from a quartzite conglomerate locally, where the basal part of the Fort Union was nearby, to maroon claystone or siltstone, sandstone, or quartzitic sandstone elsewhere. Most commonly, the base of the Willwood is marked by a light-gray silty sandstone, locally quartzitic, which forms a small bench. Locally, where quartzite conglomerate forms the base of the Willwood, the conglomerate can be traced directly to its source—the basal conglomerate of the Fort Union (fig. 4). This relationship is best observed in the

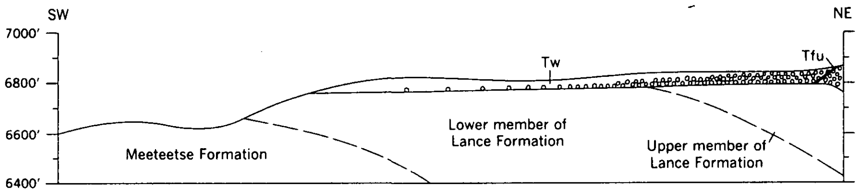

FIGURE 4.—Diagrammatic section in E½ sec. 16, T. 46 N., R. 100 W., showing unconformity at base of Willwood Formation (Tw) and southwest thinning of gravel which was derived from the conglomerate at the base of the Fort Union Formation (Tfu). The Fort Union conglomerate formed a topographic high during deposition of the lower part of the Willwood.

SW¼NE¼ sec. 16, T. 46 N., R. 100 W., where the basal conglomerate of the Willwood formed an alluvial fan abutting the Fort Union Formation. In the S½N½ sec. 12, T. 45 N., R. 100 W., many large angular blocks derived from the basal conglomerate of the Fort Union, some in excess of 5 feet in diameter, were incorporated in the basal part of the Willwood.

The Willwood is mainly claystone and siltstone, although one-third of the formation is sandstone. Both weathered and fresh grains of feldspar, many of them partly replaced by calcite, are present in the arkosic sandstone. Other rock types include a thin lens of finely crystalline limestone exposed north of Bill Dickie Draw and a thin lens of coal, 2 feet thick, at the N¼ cor. sec. 3, T. 45 N., R. 100 W. A measured section of the Willwood Formation is given as follows:

Section of the Willwood Formation in the NE¼ sec. 28, T. 46 N., R. 100 W.

Tatman Formation.	
Willwood Formation:	*Feet*
Sandstone, light-rusty-gray, very fine grained, silty; forms small ledge	4.0
Claystone, maroon and gray	11.5
Siltstone, light-buff to light-rusty-gray, sandy, calcareous	5.5
Claystone, gray; obscured	5.0
Sandstone, light-gray to light-rusty-brown, medium- to coarse-grained, arkosic; contains lenses of pebble conglomerate; locally maroon claystone near base	43.0
Claystone, gray; mostly obscured	6.0
Sandstone, light-buff-brown, coarse-grained, very calcareous; pebble conglomerate	3.0
Claystone, purplish-gray	5.5
Siltstone, gray to buff-brown, sandy; maroon claystone	7.0
Claystone, maroon, gray, and grayish-green	13.5
Sandstone, light-buff-brown, medium- to coarse-grained, arkosic; contains lenses of pebble conglomerate	7.0
Claystone, maroon; thin calcareous sandstone at top	11.5
Sandstone, light-buff-brown, very fine grained, calcareous; fractures cemented by calcite; forms ledge	6.0
Claystone and siltstone, maroon and gray	26.5
Sandstone, light-gray to pale-yellow and rusty-brown, coarse-grained; contains lenses of chert and feldspar pebble conglomerate	12.0
Claystone, maroon and gray, silty	5.5
Sandstone, light-rusty-brown, very fine grained, calcareous; contains seams of maroon claystone	3.0
Claystone, gray and maroon; mostly obscured	10.0
Sandstone, very light gray to pale-rusty-brown, very fine- to fine-grained, calcareous; forms bench	4.5
Claystone, gray and maroon; contains two thin sandstone beds	17.0
Sandstone, pale-brownish-gray to dark-rust, fine- to medium-grained, calcareous, fossiliferous	4.0
Claystone and sandy siltstone, gray and maroon; siliceous cemented light-grayish-tan very fine grained sandstone	34.0
Sandstone, pale-yellow to rusty-brown and very light gray, coarse-grained, arkosic, noncalcareous; contains pebble conglomerate lenses; angular to subround sand grains; subround to round pebbles	37.0
Claystone, gray and maroon; mostly obscured	56.0
Sandstone, light-gray, fine- to medium-grained, locally friable; commonly quartzose or conglomeratic and several feet thick	2.0
Total thickness Willwood Formation	340.0
Unconformity.	
Fort Union Formation.	

The Willwood Formation unconformably overlies the Fort Union Formation of Paleocene age and the older exposed formations in the quadrangle (pl. 1) and is overlain conformably by the Tatman Formation. The contact of the Willwood and overlying Tatman Formation is placed at the change from variegated claystone and arkosic sandstone to grayish-green bentonitic clay or carbonaceous or lignitic shale of the Tatman Formation. Locally, in the plate of the detachment fault, the Eocene Pitchfork Formation overlies the Willwood Formation in fault contact.

Several fresh-water clams (*Unio*) and parts of two turtles were found in the quadrangle, but they are not diagnostic of age. One turtle, belonging to the family Trionychidae, was tentatively identified as *Aspideretes grangeri* or *guttatus;* and the other, probably in the family Emydidae, may belong to the genus *Echmatemys* (Nicholas Hutton, written commun., Dec. 2, 1960). The Trionychids are soft-shelled turtles that dwell in ponds and streams, and the Emydids, although not strictly aquatic, live close to water.

The Willwood Formation was deposited generally along stream courses and in small marshes or swampy areas. The Willwood was deposited on a surface of low relief where resistant strata, such as the basal quarzite conglomerate of the Fort Union, formed hills 40–100 feet high. Detritus from these hills was incorporated in the lower part of the Willwood Formation in the form of alluvial fans until the hills were eventually buried by other Willwood sediments.

TATMAN FORMATION

Outcrops of the Eocene Tatman Formation are few and small in the Adam Weiss Peak quadrangle. A seemingly complete stratigraphic section, 60 feet thick, is exposed in the NE¼NE¼ sec. 8, T. 45 N., R. 100 W.; about 40 feet of the formation is present near the W¼ cor. sec. 3, T. 45 N., R. 100 W. No Tatman strata were found north of Enos Creek, except for a small wedge of much contorted olive-gray bentonitic clay in the NW¼NE¼ sec. 28, T. 46 N., R. 100 W. This small outcrop was contorted by the "bulldozing" action associated with the Enos Creek fault.

In general, the Tatman includes claystone, shale, mudstone, marl, sandstone, and minor coal. Marly brown kerogenic shale that contains abundant ostracodes and scattered fish bones and scales is a characteristic but not dominant rock type of the Tatman Formation. Thin stringers of low-grade lignite intercalated with carbonaceous shale are locally present at or near the base of the formation. A coal bed, 19 inches thick, occurs at the base of the Tatman Formation in sec. 3, T. 45 N., R. 100 W. The usual thickness of the coal beds is less than 8 inches.

The Tatman Formation is overlain comformably by the Pitchfork Formation, and the contact is placed at the change from nontuffaceous to tuffaceous sediments. This contact is mostly obscured in the area, and the formations are only locally differentiated on the map, plate 1. Where the Tatman and Pitchfork are differentiated, the Tatman is not in fault contact with the underlying strata. Where the Tatman and Pitchfork are undifferentiated, the Tatman may be in fault contact with the underlying strata.

The Tatman depositional basin includes the area of the Bighorn Basin south of the Greybull River (Loomis, 1907; Van Houten, 1944; Tourtelot, 1946; Hay, 1956; Wilson, 1964). In the Adam Weiss Peak quadrangle, the formation was deposited in shallow lakes and swamps near the western margin of the depositional basin. These peripheral deposits represent only the uppermost Tatman strata and probably have no equivalents in the central basin area where the Tatman Formation is much thicker and the upper units are missing (Rohrer and Leopold, 1963; Rohrer, 1964a, b).

Vertebrate, invertebrate, and plant fossils have been collected from the Tatman Formation. Plant fossils from 10 feet above the base of the Tatman, near the center W½W½ sec. 3, T. 45 N., R. 100 W., have been tentatively dated as early or early middle Eocene (J. A. Wolfe, written commun., Dec. 15, 1961). The fossils identified, however, were few: *Ulmus* sp., *Ficus densifolia*, *Platanophyllum whitneyi*. I. G. Sohn (written commun., Jan. 23, 1960) tentatively identified some poorly preserved ostracodes from the Tatman Formation and indicated that the Tatman is of Bridgerian provincial age (Wood, 1941).

PITCHFORK FORMATION

The Eocene Pitchfork Formation forms resistant dark-colored isolated hills on divides in the southern part of the quadrangle and on the mountains at the west edge of the quadrangle. The thickness of the Pitchfork was difficult to determine exactly because it is the main part of the crumpled Enos Creek detachment thrust sheet (fig. 5). A section about 650 feet thick was measured in the W½NW¼ sec. 28, T. 46 N., R. 100 W. This is about the maximum thickness remaining in the quadrangle, as the upper part of the Pitchfork has been removed by erosion.

The contact of the Pitchfork Formation with the underlying Tatman Formation is locally gradational. Hay (1956, p. 1880) described the basal unit of the Pitchfork as the first major influx of volcanic material, either pyroclastic or detrital. He believed, however, that the Pitchfork Formation was underlain by the Willwood Formation in most of the area covered by the Adam Weiss Peak quadrangle. At the

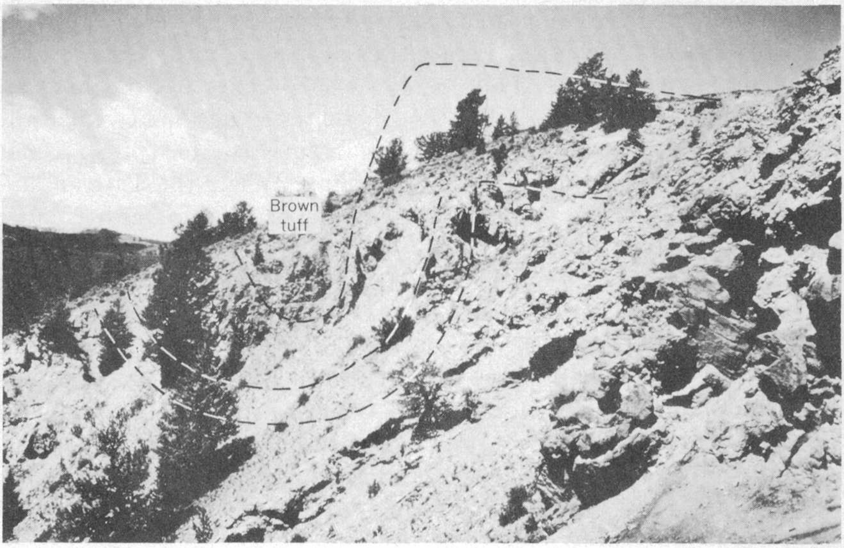

FIGURE 5.—View showing crumpled strata of the Pitchfork Formation in NW¼ sec. 28, T. 46 N., R. 100 W. Fold axes trend northwest.

only place in the quadrangle where the Pitchfork overlies the Willwood, it is in fault contact. From sec. 28, T. 46 N., R. 100 W., northward, the Pitchfork may have been laid down disconformably on top of the Willwood Formation and in the adjoining area to the west, but the rocks north of sec. 28 have been removed by later faulting and erosion in the quadrangle. Wilson (1964, p. 61), however, suggests that a thin dark-brown carbonaceous shale at the top of the Willwood represents Tatman strata in the Wood River area northwest of the quadrangle.

Two uniformly bedded units of the Pitchfork, totaling about 60 feet in thickness, are in the E½NE¼SE¼ sec. 8, T. 45 N., R. 100 W.; they represent a transition from the Tatman Formation to the Pitchfork Formation. The basal unit is a grayish-green medium-grained tuffaceous sandstone. Petrographic study indicates that the sandstone is composed of angular quartz, quartzite, alkali feldspar, biotite, and mafic minerals plus some secondary carbonate. The next higher unit is a tuffaceous sandy siltstone composed mainly of feldspar (0.01 mm in diameter), but it includes minor angular quartz grains averaging 0.2 mm in diameter. In the W½NW¼ sec. 28, T. 46 N., R. 100 W., the basal part of the Pitchfork is different lithically. Here, the basal unit is a dolomitic tuffaceous sandstone in which dolomite replaces feldspar. Underlying this basal unit is an 8-foot concealed zone which overlies light-buff-gray fine-grained arkosic sandstone of the Willwood Formation.

The Pitchfork strata overlying the basal units are composed of sandstone, siltstone, and channel conglomerate and some interbedded porcelanite and welded lapilli tuff. The sandstone, siltstone, and conglomerate are composed mainly of epiclastic andesitic tuff. The conglomerates commonly consist of well-rounded andesite cobbles and boulders in a hard indurated tuff matrix. The tuffaceous beds are steel gray, greenish gray, and grayish green. The porcelanites are white to pale green. The green color of the rocks is due to celadonite, which is a common constituent in the formation. The celadonite, identified by X-ray methods by L. G. Schultz, is commonly associated with cristobalite in these tuffs.

Scattered gastropods and pelecypods were found about 55 feet above the base in the tuffaceous siltstone of the Pitchfork Formation in the E½NE¼SE¼ sec. 8, T. 45 N., R. 100 W. Gastropods were also found about 440 feet above the base in a grayish-green tuff sandstone of the Pitchfork Formation in the SW¼NW¼SW¼ sec. 30, T. 46 N., R. 100 W. These gastropods are *Bellamya* n. sp. and *Pleurocera tenera* (Hall), according to D. W. Taylor (written commun., Jan. 22, 1963); both indicate a fresh-water environment.

J. A. Wolfe (written commun., Dec. 15, 1961) identified the following flora from the Pitchfork Formation:

Locality: NE¼SE¼NW¼ sec. 35, T. 45 N., R. 101 W.

Juglandaceae, n. gen. and sp.
Ficus densifolia Knowl.
Platanophyllum angustiloba serrata MacG.
P. whitneyi (Lesq.) MacG.
Koelreuteria mixta (Lesq.) Brown

Locality: C N½ sec. 28, T. 46 N., R. 100 W.

Platanophyllum angustiloba serrata MacG.
P. whitneyi (Lesq.) MacG.

In addition, the porcelanite contains plant impressions similar to *Equisetum*.

Both the flora and the fauna indicate that the Pitchfork was deposited in a lake when the climate was warm and moist, probably subtropical, and they support the suggestion of Hay (1956, p. 1888) that the lacustrine environment that existed during Tatman time persisted into Pitchfork time. Although most volcanic detritus in the Pitchfork exposed in the quadrangle was deposited in a lacustrine environment, some coarse debris from the Yellowstone-Absaroka volcanic province was deposited by streams. In the Cottonwood Creek area, south of the quadrangle, the influx of coarse volcanic detritus temporarily ceased during early Pitchfork time and deposits characteristic of the Tatman Formation were again laid down (Hay, 1956, p. 1879).

Recently, the age and correlation of the Pitchfork have been made more precise. The Pitchfork was correlated by Hay (1956, p. 1884) with the "early basic breccia" in the Yellowstone-Absaroka volcanic province and with the Aycross Formation and was assigned a middle Eocene age. Features such as color, texture, origin, and mineralogy imply correlation with the Tepee Trail Formation (Love, 1939, p. 74–77; Hay, 1956, p. 1869–1877). Although the Tepee Trail was provisionally dated as late Eocene (Love, 1939, p. 78), the writer has made substantial floral collections from the lower 700 feet of the Tepee Trail. These collections support a middle Eocene age for the formation (H. D. MacGinitie, written commun., Dec. 9, 1964). Van Houten (1944, p. 200–201) concluded that the early basic breccia is possibly both middle and late Eocene. The rounding of the cobbles and boulders in the Pitchfork conglomerates indicates a possible age difference from breccia-type accumulations; however, this rounding could have occurred in a very short time. Houston (1963, table 3) has indicated that the Tepee Trail is in part equivalent to the Pitchfork; Wilson (1963, p. 19) shows a similar correlation. Intertonguing of Pitchfork and Tatman strata in the Cottonwood Creek area implies a middle Eocene age for the lower part of the Pitchfork. It is this interval and part of the underlying Tatman which are considered correlative of the intercalated Tatman carbonaceous shales and tuffaceous beds on Lysite Mountain. The presence of tuffaceous sediments in this Tatman section is indicative of the correlation and is further supported by the contention that these deposits wedge out southward (Love, 1964, p. 44).

TERRACE GRAVEL

An isolated remnant of Quaternary terrace gravel forms a thin veneer on a small bench about 180 feet above the Grass Creek valley floor in the S½NE¼SE¼ sec. 9, T. 45 N., R. 100 W. The gravel consists of pebbles and cobbles of basalt and andesitic volcanic rocks, a few dense lithographic cherty dolomite cobbles probably derived from a Paleozoic formation, and scattered quartzite cobbles. The terrace remnant is considered Pleistocene in age on the basis of position with respect to the modern alluvial deposits.

ALLUVIUM

Alluvium in the quadrangle consists of valley-fill and stream-terrace deposits composed of debris from nearby hillsides. The present streams are incised as much as 35 feet into the alluvium, and locally the thickness of the alluvium exceeds 50 feet. The coarse detritus above stream level is locally a well-indurated conglomerate cemented by calcite and iron oxide. Near the mouth of Renner Draw, this conglomerate consists of ironstone and a few quartzite pebbles and cobbles in a matrix of sandstone. The conglomerate is poorly sorted and nonstratified, and the fine- to coarse-grained sandstone matrix is poorly consolidated. Most of the sand in the matrix is derived from the Mesaverde Formation. Similar alluvial conglomerates occur also at the confluence of the three draws near the center S½ sec. 17, T. 46 N., R. 99 W., and along Enos Creek near the center NE¼SE¼ sec. 26, T. 46 N., R. 100 W.

A channel conglomerate, about 50 feet thick, occurs on the south side of Left Hand Creek, near the NE. cor. sec. 5, T. 46 N., R. 99 W., and can be subdivided into three units. The lower unit, 15–30 feet thick, consists of poorly to well-indurated sandstone and quartzite pebbles, cobbles, and boulders in a fine- to coarse-grained light-brownish-gray sandstone matrix. The middle unit, 1–3 feet thick, consists of well-indurated light-gray fine- to coarse-grained sandstone that contains pebbles and cobbles in the basal few inches. The upper unit, about 18 feet thick, consists of consolidated and unconsolidated silt, sand, and coarse gravel. The cobbles and pebbles are composed of sandstone, quartzite, ironstone, claystone, siltstone, and andesitic volcanic rocks and are calcite cemented. Irregular bedding indicates that the channel conglomerate dips 1.5° downstream in an easterly direction. The contact with the underlying Mesaverde Formation is marked by angular sandstone boulders in the base of the conglomerate.

Some of the alluvium along the principal watercourses may be of Pleistocene age, but the relative amounts of Pleistocene alluvium and Recent alluvium were not determined. A stick of lignitized wood from an isolated patch of alluvium near the center E½ sec. 33, T. 47 N., R. 100 W., was found to be 34,700± 2,200 years B.P. (before present), according to radiocarbon dating (Isotopes, Inc. No. I–418). This age determination places it within the pre-Pinedale and post-Bull Lake interglaciation of the Pleistocene. The isolated patch of alluvium in the NW¼ sec. 4, T. 45 N., R. 100 W., may be of a like age; whereas the terrace gravel in the NE¼SE¼ sec. 9, same township, is probably older.

The Recent alluvium is as old as 2,080± 300 years B.P. (USGS Lab. No. W–1199), as dated by radiocarbon methods on charcoal from an early man campsite found near Grass Creek.

The partial skull of a large ram, *Ovis canadensis* Shaw (Rocky Mountain Bighorn sheep), was found in Enos Creek just above the trail crossing in the NW¼ sec. 35, T. 46 N., R. 100 W. The degree of preservation of the bone structure indicated that the skull was washed out of the alluvial fill. G. Edward Lewis (written commun., Sept. 26, 1960) identified the skull and noted that the species ranges in age from Pleistocene through Recent. No definite age, however, could be assigned to the skull because the specimen was not suitable for radiocarbon dating.

LANDSLIDE DEPOSITS

Landslide deposits in the quadrangle were formed by slump and earthflow or a combination of the two. The two landslides in sec. 11, T. 45 N., R. 100 W., are typical slumps formed from oversteepening of slope that resulted in failure of supporting beds. Typical earthflows formed in the SE¼ sec. 21, T. 46 N., R. 100 W., where water-saturated clayey beds moved by mass flowage. Landslide deposits resulting from a combination of both slump and earthflow movement are typified by the slide in the SW¼ sec. 21, T. 46 N., R. 100 W.

GEOMORPHOLOGY

Alluvial deposits of at least two ages were mapped in the quadrangle, but because one of these deposits is composite in nature, the writer believes that there are probably at least three ages of alluviation represented. The oldest deposits are represented by terrace gravel about 180 feet above Grass Creek in the S½NE¼SE¼ sec. 9, T. 45 N., R. 100 W. The terrace gravel is probably pre-Pinedale in age because of its height above the modern flood plain of Grass Creek. The intermediate deposits are represented by isolated patches of alluvium in the center E½ sec. 33, T. 47 N., R. 100 W., and in the NW¼ sec. 4, T. 45 N., R. 100 W. The deposit in T. 47 N., R. 100 W., has been dated by radiocarbon methods as 34,700$\pm$ 2,200 years B.P., indicating that it is pre-Pinedale in age. These two alluvial deposits, when combined with younger alluvium, form a composite terrace deposit that is about 35 feet above the modern flood plain. The younger alluvium is as old as 2,080$\pm$ 300 years B.P., as dated by radiocarbon methods on charcoal from an early man campsite found near Grass Creek. The youngest terrace deposits are, therefore, known to range from probable Pinedale age through Recent; hence, downcutting took place before and after deposition of the terrace gravel and again in historic time. Other alluvial deposits intermediate in age between pre-Pinedale and Recent are most likely also included in the intermediate and youngest terrace deposits, although they were not differentiated.

STRUCTURE

FOLDS

The principal folds in the quadrangle are shown on the map (pl. 1) by structure contours drawn on the top of the Cody Shale. The doubly plunging Enos Creek anticline is in the central part of the map area, and the axial trace forms an arcuate pattern concave toward the east. The structural closure is about 1,000 feet at the contour horizon. The contours indicate structural terraces along both the southeast and northeast plunges. Farther north, the Gooseberry anticline extends southward into the northwest corner of the quadrangle and is fairly symmetrical. The small anticlinal nose about 2 miles east of the Gooseberry anticline is the south plunge of the Northeast Gooseberry anticline, which is outside the map area. The two folds are approximately parallel.

Walker dome, at the east edge of the map area, is a small fold on the west flank of the Little Grass Creek anticline, which is farther east outside the quadrangle. Walker dome is separated from the northeast plunge of Enos Creek anticline by a saddle which Hewett (1926, p. 62) called the Enos Creek syncline.

Mausoleum syncline, in the northeast corner of the quadrangle, trends east-northeast. It is a fork of the Gooseberry syncline, which is outside the map area, and is named after the mausoleum erected near the axis in the SW¼ sec. 32, T. 47 N., R. 99 W.

The Grass Creek syncline is several miles long and trends east-southeast, south of Walker dome.

Twin Buttes syncline is a deep depression south of the Enos Creek anticline. The northeast and west flanks are steep, whereas the south and east flanks (outside the quadrangle) are relatively gentle. The syncline is bounded on the west, south of Grass Creek, by the Skelton anticline (not labeled on map), which extends for only a short distance into the quadrangle.

Left Hand syncline (pl. 1), south of Gooseberry anticline, is a deep east-west asymmetrical trough with a steep north flank and a gentle south flank. It is named after Left Hand Creek, which crosses the syncline in sec. 15, T. 46 N., R. 100 W. The south flank ascends gradually to the structural terrace between Grass Creek and Enos Creek in the southwestern part of the quadrangle.

The folds in the quadrangle formed during late Paleocene time. Two orogenic pulses within this time interval are inferred from structural relations. The similarities in the trend and configuration of the Left Hand and Grass Creek synclines suggest that they formed a single structure that was broken when the Enos Creek anticline formed. The similarities probably imply that the structures north of the Left Hand-

Grass Creek synclines were formed in part at the same time as the synclines. This implication is further supported by the northward warping of the eastern part of the Left Hand syncline and the progressive development of folds basinward during early Tertiary (Hewett, 1926, p. 68; Jepsen and Van Houten, 1947, p. 144).

Alternate interpretations to the two ages of the folds are: (1) there was a general northward tilting and the structures transverse to the direction of tilt were formed later, or (2) the reverse occurred. The inference in either of these interpretations is that the Gooseberry and Enos Creek anticlines are contemporaneous. Whichever one is correct has a significant bearing on the oil and gas occurrences in the area.

ENOS CREEK DETACHMENT THRUST

The most impressive structure in the quadrangle, here named the Enos Creek detachment thrust, is a décollement following the usage of Pierce (1957, p. 591–593). The first record of this feature was possibly made by Rouse (1940, p. 1422–1423), who observed folded Pitchfork strata lying upon the undisturbed Willwood Formation in the Wood River area, but he made no attempt to analyze the structures. The Enos Creek detachment thrust, named for the area in which it was first recognized, involves the entire Pitchfork Formation and, locally, the Tatman and Willwood Formations within the quadrangle, but it does not affect pre-Willwood strata. The thrust plane nearly parallels the bedding of the Tatman and Willwood Formations and places the Pitchfork on one of these two formations. The detached mass moved on a nearly horizontal plane; however, there are undulations in the glide plane. The Enos Creek thrust indicates that detachment thrusts are more common to the eastern periphery of the Absaroka-Yellowstone volcanic province than was thought when only the Heart Mountain thrust was recognized.

Some information about the direction of movement of the Enos Creek thrust can be ascertained from bedding attitudes in the Pitchfork and Tatman Formations. At Adam Weiss Peak, the Pitchfork strata are tightly folded into a northwest-trending anticline. Steeply dipping Tatman strata are exposed in the core of this anticline where erosion has breached the axis. At Twin Buttes, between Grass Creek and Little Grass Creek, the Pitchfork strata dip a few degrees north and most of the Tatman Formation is cut out by the thrust. Much of the Pitchfork strata in and adjacent to the NW¼ sec. 28, T. 46 N., R. 100 W., is tightly folded into northwest-trending anticlines and synclines (fig. 5), but folding becomes less tight in a westerly direction. The Pitchfork Formation on Squaw Teats (or Squaw Buttes), located about 15 miles northeast of this quadrangle, is folded, and the fold axes trend northwestward and show no indications of the slump brecciation suggested by Hay (1956, p. 1880). The tight folds and trend of the folds of Pitchfork strata on Squaw Teats imply that the beds were folded during the same deformation of Pitchfork strata in the Adam Weiss Peak quadrangle. The deformed strata on Squaw Teats are probably isolated remnants of the Enos Creek detachment thrust. These bedding attitudes and fold trends lead the writer to believe that the initial separation of the Enos Creek detachment sheet was to the southwest or west of the Adam Weiss Peak quadrangle.

Exceptions to the general northwest strike of bedding in the Pitchfork Formation exist at some places in the quadrangle. In sec. 4, T. 45 N., R. 100 W., the attitudes of the tuffs in the Pitchfork Formation are heterogeneous, perhaps indicating differential movement within the thrust sheet. On the next ridge north, however, south of Enos Creek, the attitudes of the tuffs again strike northwestward. The two allochthonous patches of Pitchfork Formation in the SE¼NE¼ sec. 27, T. 46 N., R. 100 W., are too small to add detailed information to the overall structural interpretation of the Enos Creek detachment thrust.

The thrust plane locally is undulatory, and these undulations seem to be linear features as much as half a mile long which are either parallel or perpendicular to the direction of thrust movement. In the SW¼NW¼ sec. 3, T. 45 N., R. 100 W., the undulation on the glide plane has 120–160 feet of relief. At Adam Weiss Peak the glide-plane relief is locally in excess of 200 feet. At these places the thrust plane locally attains a vertical or near-vertical attitude where the underlying plastic claystone and shale have been trenched parallel to the movement of the thrust sheet. The trenching forms northeast-trending undulations that indicate the direction of movement of the thrust sheet. At Twin Buttes the relief on the fault plane is about 140 feet, and the trend of the undulation in the fault plane is perpendicular to the direction of thrust movement. At this place the thrust moved from an area underlain by resistant strata to an area of less resistant strata. Some of the relief on the glide plane at Twin Buttes may be related to the normal fault in the S½ sec. 12, T. 45 N., R. 100 W.

The general northwest trend of the fold axes, the lack of deformation in underlying formations, the decreasing frequency and amplitude of the folds west of the map area, the northeast trenching of underlying formations, and the relatively restricted stratigraphic position of the Enos Creek thrust plane indicate that the Pitchfork and Tatman strata were deformed by a mass displacement of material that originated southwest or west of the Adam Weiss Peak quadrangle.

Some interpretations regarding the movement and mobility of the thrust sheet may be made from the Pitchfork deformation. The decreasing complexity of the deformation from northeast to southwest implies that movement continued at the rear of the mass after frontal movement stopped. The fact that the mass has not been broken into blocks indicates that it moved for the most part as a unit. If this had not occurred, a fault similar to the Heart Mountain and Reef Creek detachment thrusts, in which blocks of the thrust sheet are structurally separated, would have formed (Pierce, 1957; 1960). The foregoing implies that the Enos Creek detachment thrust movement was relatively rapid and continuous until the front of the mass "stubbed its toe," whereupon the momentum at the rear of the thrust caused tight folds toward the front of the thrust plate. The complexity of the folds was probably increased by the irregular thrust-plane surface and irregularities in the sole of the thrust. The amplitude and frequency of the folds diminished toward the rear of the thrust sheet as gravitational energy was expended. The concept that this is indeed a detachment thrust rather than a thrust with roots is strongly supported by the decreasing intensity of folding toward the source area, the general lack of deformation west of the gently folded area, and the general lack of imbricate structure. Where the shearing took place in relation to the parent body remains unanswered. Mechanical analyses comparable to those by Hubbert and Rubey (1959) may yield clues as to how far the detached mass moved.

The age of the Enos Creek thrust is not determined precisely; it is younger than the middle Eocene Pitchfork Formation and older than Pleistocene gravel. This décollement is in the same provincial area as the South Fork and Heart Mountain thrusts. The South Fork and Heart Mountain detachments are thought to be older than late Eocene (Pierce, 1957, p. 624). The Enos Creek gravity sliding may in some way be related to the Miocene(?) igneous intrusions (Wilson, 1964, p. 75) in the area a few miles west of the Adam Weiss Peak quadrangle.

Pierce (1957, p. 615, 624) suggested that volcanic activity or intrusions were triggering devices for the Heart Mountain and South Fork detachment thrusts. Possibly earthquakes associated with volcanism in the Yellowstone-Absaroka volcanic province triggered the Enos Creek detachment thrust. Presumably, movement of the Enos Creek thrust was facilitated where water-saturated plastic clays occurred in the Tatman and Willwood Formations. Hubbert and Rubey (1959, p. 115–116) concluded that where a water-saturated stratum is gravitationally loaded by increasing thickness of overburden the hydrostatic pressure increases, so that the saturated stratum approaches the properties of the contained fluid; that is, the frictional coefficient decreases toward zero. Then the overlying strata glide on the saturated stratum if a triggering mechanism sets it into motion.

NORMAL FAULTS

Several normal faults are present in the quadrangle (pl. 1). These are mostly well exposed, although a few are extended or inferred from geologic relations. Each fault and its displacement is briefly mentioned. The small fault south of Left Hand Creek has Willwood strata abutting the Meeteetse Formation. The fault is nearly vertical and has about 40 feet of offset. The irregular fault in the SE¼ sec. 23 and the SW¼ sec. 24, T. 46 N., R. 100 W., north of the Enos Creek field, has a relatively shallow dip and a maximum throw of about 110 feet. The throw decreases rapidly at the west end and less rapidly at the east end. It is possible that the main trace of this fault, near its east end, extends down the bottom of the canyon and that part of the fault trace shown represents a small secondary slice. The fault in the SW¼ sec. 24 that ends near the section corner has more than 50 feet of displacement, which decreases gradually toward each end. This fault dips steeply to the northwest, resulting in a small graben between it and the preceding fault. It seems likely that these two faults connect in the subsurface. The first fault north of the Enos Creek field is vertical and offsets the strata more than 10 feet, which is the displacement observed along the small fault east of the Enos Creek field. Vertical displacement along the fault 1 mile southeast of the Enos Creek field is 120 feet. This offset decreases abruptly at the west end of the fault and gradually toward the east end, where it blends into a small monoclinal fold.

The series of faults along the southern margin of the map are significant in that they have greater stratigraphic throw than the other normal faults. The fault near the southwest corner of the quadrangle is vertical, and the offset is more than 180 feet but probably does not exceed 240 feet. This fault is inferred to extend about a mile under the alluvium of Grass Creek. The inference is based on the presence of Cody strata south of the creek and its absence north of the creek. The irregular fault in sec. 11 dips northward about 50° and has a vertical displacement of about 200 feet. This fault may connect in the subsurface with the fault in the southwest corner of the quadrangle. Stratigraphic throw on the vertical fault in the S½ sec. 12, T. 46 N., R. 100 W., is about 330 feet, but it decreases abruptly westward. This fault extends under the alluvium of Little Grass Creek to the fault trending along that creek. The Little Grass Creek fault is inferred from structural and stratigraphic data. The amount of throw on this fault is unknown, but it is thought to be about 200 feet or more. The length of the fault is also indefinite, although the straightness of the valley reach suggests a length greater than shown. The small fault in the NE1/4 sec. 7, T. 45 N., R. 99 W., east of Little Grass Creek, has a vertical displacement near 100 feet. The fault near the southeast corner of the map is inferred from the difference in elevation of nearly 200 feet of the contact between the Mesaverde and Willwood Formations on opposite sides of the fault. The fault is probably a continuation of the fault mapped by Hewett (1926, pl. 3).

Pronounced straight valley segments, extending from 1 to more than 3 miles, occur along the principal watercourses. Except for the Left Hand Creek segment which is related to folding, the lineaments suggest fracture control. Detailed study of well logs in the Enos Creek field failed to reveal the existence of a major fault in that vicinity.

The normal faults are thought to be of two different ages. Those faults that traverse the crest and east side of Enos Creek anticline possibly resulted from the folding of that structure and are, therefore, thought to be virtually contemporaneous with the late Paleocene deformation. With the possible exception of the fault in Little Grass Creek, the other faults offset the Willwood Formation, which was deposited after the Paleocene deformation. This group of younger faults may be the same age as the large fault near the southwest corner of the quadrangle which occurred after the Enos Creek thrust and before deposition of the high terrace gravel.

ECONOMIC GEOLOGY

OIL AND GAS

Oil and gas were first discovered on the Enos Creek anticline in 1924 when a small volume of gas was found in the Frontier Formation. The well remained shut in until 1948 when the first oil was produced on this fold. Of the six wells which were drilled (table 1) in the Enos Creek field, two produced oil and one produced gas. The deepest stratigraphic penetration was about 240 feet into the Madison Formation (pl. 2). Oil was produced from the Tensleep and Park City Formations. The field was abandoned in 1961. Two dry holes were drilled on the Enos Creek anticline outside the immediate oil-field area. One, in sec. 7, T. 46 N., R. 99 W., on the structural terrace at the north end of the anticline, had a show of gas in the Frontier Formation and a show of oil in the Dinwoody Formation. The other, southeast of the Enos Creek field, sec. 31, T. 46 N., R. 99 W., apparently did not get through the surface formation.

Oil was discovered on the Gooseberry anticline in 1937 when both the Tensleep and Park City Formations were found to be productive. In all, 11 wells were drilled on this structure, 8 of which produced oil. Only the southernmost 3 of these 11 wells, however, are within the Adam Weiss Peak quadrangle. The producing wells are along the trace of the anticlinal axis or east of this axis. Water was found in the wells on the west side of the axial trace. The deepest well, the northernmost in the field, was drilled about 500 feet into the Madison Limestone and had a show of oil.

TABLE 1.—*Wells drilled for oil and gas in the Adam Weiss Peak Quadrangle*

Operator and well No.	Location	Date drilling completed	Total depth (feet)	Lowest formation reached	Status and producing zone
Richfield Oil Co. 1	NW¼SE¼ sec. 3, T. 45 N., R. 100 W.	11-11-59	5,704	Chugwater	Dry hole.
Pure Oil Co. 1	SW¼SW¼ sec. 4, T. 45 N., R. 100 W.	11- 1-60	7,203	Tensleep	Produces oil from Chugwater Formation.
Superior Oil Co. 27-7.	NE¼SW¼SW¼ sec. 7, T. 46 N., R. 99 W.	12-16-54	7,911	do	Abandoned. Show of oil in Dinwoody Formation.
Prairie Oil & Gas Co. 1.	SE¼SW¼SE¼ sec. 31, T. 46 N., R. 99 W.	8-20-24	505	Mesaverde	Dry hole.
Walker Dome Field					
Ohio Oil Co. 2-F	SE¼NE¼NE¼ sec. 8, T. 46 N., R. 99 W.	1- 2-59	3,104	Frontier	Produces oil from Torchlight Sandstone Member of Hintze (1915) in Frontier Formation.
Forest Oil Corp. 1	SE¼NE¼NE¼ sec. 8, T. 46 N., R. 99 W.	8-15-53	6,965	Tensleep	Produces oil from Park City Formation.
King-Stevenson Oil 1.	NE¼SW¼NE¼ sec. 8, T. 46 N., R. 99 W.	5- 3-60	3,500	Frontier	Dry hole.
Ohio Oil Co. 1	E½SE¼NE¼ sec. 8, T. 46 N., R. 99 W.	1930?	4,412	Cloverly(?)	Produces gas from Frontier Formation.
Enos Creek Field					
Ohio Oil Co. 1	SE¼SW¼NW¼ sec. 25, T. 46 N., R. 100 W.	8-25-48	7,139	Madison	Produced oil from Tensleep and Park City Formations. Abandoned 1961.
Ohio Oil Co. 2	S½NW¼NW¼ sec. 25, T. 46 N., R. 100 W.	3-13-49	6,554	Tensleep	Do.
Ohio Oil Co. 3-E	SW¼NE¼NW¼ sec. 25, T. 46 N., R. 100 W.	5- 7-51	6,445	Park City	Dry hole.
Grass Creek Oil Co. 1.	W½SW¼NW¼ sec. 25, T. 46 N., R. 100 W.	1916	2,435	Frontier	Dry hole; location from U.S. Geol. Survey Bull. 656, p. 159.
Ohio Oil Co. 1	NE¼SE¼NE¼ sec. 26, T. 46 N., R. 100 W.	1924	3,992	Cloverly	Originally drilled in 1924. Shut in until 1948. Produced gas from Frontier Formation. Abandoned 1961.
Ohio Oil Co. 4	SE¼SE¼NE¼ sec. 26, T. 46 N., R. 100 W.	1- 3-56	6,579	Tensleep	Dry hole.
Gooseberry Field					
General Petroleum Corp. 5.	N½NW¼SW¼ sec. 33, T. 47 N., R. 100 W.	5-26-49	5,970	Park City	Produces oil from Park City Formation.
Mobil Producing Co. 8.	SW¼NE¼SW¼ sec. 33, T. 47 N., R. 100 W.	12- 5-54	6,400	Tensleep	Produces oil from Tensleep Sandstone.
Mobil Producing Co. 13.	SW¼SE¼SW¼ sec. 33, T. 47 N., R. 100 W.	8-29-56	6,305	do	Do.

Oil and gas on Walker dome were first discovered in 1930 when a small gas reservoir was found in the Frontier Formation. The well was completed for production in 1934, but it remained shut in until the oil wells were drilled in the Walker dome and the Enos Creeek fields, whereupon the gas was used to operate pumps. The first oil well on Walker dome was drilled in 1953; 15 wells have been drilled, 2 of which were dry holes because they were located too far down the flanks of the structure. The gas well, two oil wells, and one of the dry holes are in the Adam Weiss Peak quadrangle (table 1). Oil is produced from the Park City and Frontier Formations. The deepest drilling in this field has gone only to the Tensleep Sandstone; however, a well in the nearby Little Grass Creek field penetrated about 120 feet into the Madison Limestone.

The presence of favorable reservoir rocks in and adjacent to the Adam Weiss Peak quadrangle suggests that further production of oil may be possible in this area.

Structural features in the Adam Weiss Peak quadrangle lend further support to the possibility that additional oil traps may be present. A graben north of the Enos Creek field cuts the crest of the anticline. Displacement along the bounding faults extends into the Cody Shale and possibly to an appreciable depth below it. A possible structural trap resulting from this graben may be just north of the faults. Another potentially productive area may occur along the southeast plunge of the Enos Creek anticline where the Little Grass Creek fault extends for an unknown distance down the Grass Creek valley. If this fault cuts the crest of the anticline to an appreciable depth, it is possible that an oil accumulation has occurred in this general vicinity. The fault and linear trend of the valley are believed to be caused by structural deformation in the basement rocks. These possibilities are, however, in part negated if the first of the suggested structural interpretations (p. A27) is accepted on a strictly structural basis. The possibility that the Left Hand-Grass Creek synclinal trend was the first structure to form and the Enos Creek anticline formed during a later phase of deformation is supported by the small Enos Creek field reservoir area as related to the 1,000 feet of structural closure.

Drilling at the nearby Skelton anticline resulted in an oil discovery in the upper sandstone of the Sundance Formation in late 1963. Below the Sundance are the Tensleep Sandstone and Park City (previously recorded as "Embar" or "Phosphoria" by many geologists) Formation of Permian age, which are known oil reservoirs in many Bighorn Basin fields. The well in the SW¼SW¼ sec. 4, T. 45 N., R. 100 W., was abandoned in 1960, but it was worked over and converted to a small oil producer in 1964. Production is from a sandstone member about 230 feet below the top of the Chugwater Formation.

Oil saturation occurs in the Darwin Sandstone Member of the Amsden Formation in the Oregon Basin field, but this may be due to possible intercommunicating reservoirs (Walton, 1947, p. 220). No oil has been reported from this formation in nearby fields.

The Madison Limestone of Mississippian age is a known oil reservoir in several fields near the Adam Weiss Peak quadrangle. A low-gravity oil has been found in the Madison in the Hamilton dome field about 15 miles southeast of the Enos Creek field (Wyoming Geol. Assoc. Guidebook, 1952). In the Oregon Basin field (Walton, 1947, p. 216), porous zones in the lower 500 feet of the formation are important oil reservoirs, whereas in the Grass Creek field, the upper part of the formation is the main oil reservoir. One well in the Adam Weiss Peak quadrangle penetrated about 240 feet into the Madison Limestone, but no oil was found.

A hole to the granitic basement rocks in the Grass Creek field, 4½ miles east of the quadrangle, showed 1,680 feet of strata below the Madison and above the granitic basement rocks. Water is present at several zones in this interval.

COAL

Coal occurs in the Mesaverde, Meeteetse, Fort Union, Willwood, and Tatman Formations. The coal beds are lenticular and have not been exploited in the quadrangle. Beds not shown on the map are indicated in the stratigraphic sections or discussion of stratigraphy.

Coal in the Mesaverde Formation occurs mainly in the lower part of the formation just above the basal sandstone in what has been called the Little Buffalo group of coal beds (Hewett, 1926, pl. 25). This coal-bearing interval is fairly persistent, but individual beds in the zone are lenticular. The thickness of the zone varies, and the individual coal beds range in thickness from 4 feet southwest of the Enos Creek oil field to 10 feet at a depth of 450 feet in the oil well in the SW¼ SW¼ sec. 4, T. 45 N., R. 100 W. Analyses of a sample of coal from an outcropping coal bed almost 2 feet thick in the W½SW¼NW¼ NE¼ sec. 15, T. 45 N., R. 100 W., yielded the following results:

Coal	*Btu*
As received	10,710
Moisture free	11,750
Moisture and ash free	12,750

Coal beds in the Meeteetse formation are lenticular, and few extend laterally more than a few hundred feet. The coal beds are numerous and thin (p. A13–A14), usually less than about a foot in thickness; but some are as much as 2.5 feet thick, and these are not limited to any particular part of the formation. One bed, located 225 feet below the top of the formation in the N½SE¼NE¼ sec. 30, T. 46 N.,

R. 99 W., is 2.8 feet thick. The thickest bed of coal was observed in outcrops along the fault in the SE¼SE¼SW¼ sec. 12, T. 45 N., R. 100 W., a few feet below the top of the formation. This bed is 6 feet 3 inches thick and is relatively persistent laterally. Half a mile southeast, the coal bed is 4 feet thick. Near the center S½N½ sec. 7, T. 45 N., R. 99 W., the bed is 8 feet thick, but it contains abundant carbonaceous shale partings. From here, the coal-bearing unit gains additional shale eastward. The coal bed thins in the same direction as the Meeteetse Formation thins. In general, however, the outcrops of coal beds in the Meeteetse in the quadrangle are too poor to determine the overall trend of thinning of the coal. Analyses of a sample of coal from the outcrop in the center SE¼SE¼SW¼ sec. 12, T. 45 N., R. 100 W., yielded the following results:

Coal	*Btu*
As received	7,240
Moisture free	8,370
Moisture and ash free	12,450

The only coal bed of any importance found in the Fort Union Formation is 22 feet thick along the axis of the Grass Creek syncline. Unfortunately, the bed underlies only a small area in the quadrangle. In the adjacent Grass Creek quadrangle, the Fort Union contains a coal bed that is stratigraphically lower than the 22-foot bed (Hewett, 1926, p. 100). This bed is absent in the Adam Weiss Peak quadrangle, but it may be represented by a carbonaceous shale.

Only a single coal lens was found in the Willwood Formation, indicating that conditions necessary for the formation of coal were generally lacking during the early Eocene. The coal bed in the Willwood is 2 feet thick near the N¼ cor. sec. 3, T. 45 N., R. 100 W., but wedges out in a short distance. A sample from the outcrop at this locality yielded the following results upon analysis:

Coal	*Btu*
As received	4,110
Moisture free	4,850

Locally, thin coal lenses occur at the base of the Tatman Formation. A coal bed, 1 foot 7 inches thick, underlies a small part of the ridge about 400 feet east of the W¼ cor. sec. 3, T. 45 N., R. 100 W. No coal sample from the Tatman was collected for analysis, but the grade of these coals is probably lower than that of the coals in the Willwood Formation. All coal analyses were made by the U.S. Bureau of Mines, Pittsburgh, Pa.

OIL SHALE

The Tatman Formation of middle Eocene age contains beds of kerogenic shale. These kerogenic shales are generally too thin, of too limited lateral extent, and of too low yield within the quadrangle to be of commercial importance. An analysis of a selected high-grade sample of shale indicated an oil content of 14.2 gallons per ton. This oil content is much higher than the average of 5.5 gallons per ton obtained from two other samples. The oil shale analyses were made by the U.S. Bureau of Mines, Laramie, Wyo. (written commun., May 28, 1962, and Oct. 25, 1961).

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