GEOLOGY OF THE BRADLEY MOUNTAIN AREA
LINCOLN COUNTY, WYOMING

by

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ABSTRACT

The Bradley Mountain area lies near the north end of a trough of thick Paleozoic and Mesozoic sediments. About 18,000 feet of these strata crop out in the Bradley Mountain area, but they thicken to over 40,000 feet near the Idaho-Utah-Wyoming corner. Sometime between the late Cretaceous and the early Eocene, probably during the Paleocene stage of the Laramide revolution, the area was sliced into five thrust sheets, each sheet overriding eastward. From east to west these are the Fire Trail, Absaroka, St John, Ferry Peak, and Needle Peak thrusts. The same compressional forces which produced them also bent the beds of the various sheets into folds of various intensities. In the Bradley Mountain area the Fire Trail anticline and Bradley Mountain syncline were thus formed.

During the Miocene, the western edge of the area was cut by the high angle, normal Grand Valley fault, which produced a trough, similar to that of the Hoback fault depression to the east, in which the Camp Davis conglomerates and tuffs were deposited.

INTRODUCTION

Location of the Area

The Bradley mountain area is located near the western boundary of Lincoln county, Wyoming. It is bounded on the north by the westward flowing Snake River and on the south and west by Greys River, which empties into the Snake River at the northwest corner of the area. Skull Creek and the creek to the north define the eastern edge of the area. The relief is about 3600 feet.

Bradley mountain lies between the Snake River Range, north of the Snake River, and the Salt River Range, south of Greys River. (See plate III) To the west is Grand Valley and to the east is Elk Mountain.

The area is accessible only from the Greys River road. The strong current of the Snake River between the Snake River Canyon road and Bradley mountain is a rather effective barrier to the north slopes.

Purpose of Study

Field work on the Bradley mountain area was undertaken during three weeks in August, 1946, as a part of the Camp Davis program to complete the unmapped areas in the Jackson and Irwin Quadrangles. The work was also intended to provide data for a master's thesis by the author.

Acknowledgments

Field work, as well as the writing of this report, has been carried out under the direction of Prof. A. J. Eardley, who has offered many helpful suggestions. During the first week in the field, the writer was assisted by Lucile Otton of the University of Illinois and, in return, saw much of the Elk mountain area that she was then mapping to the east. Janet Cook of the University of Michigan was of great assistance in the field during the last two weeks. Much aid in the preparation of the photographs has been given by M. V. Denny.

Table of Thicknesses

BRADLEY MOUNTAIN AREA COMPARED WITH GROS VENTRE MOUNTAINS*

Age	Name of formation***	Thicknesses in feet Bradley Mt.	Gros Ventre
Miocene	Camp Davis	2,000	0-1000
M. Eocene	Pass Peak**	2,000±	
L. Eocene	Hoback**	15,000	
Paleocene	Pinyon		0-2000
U. Cretaceous	Mesaverde		4,030
"	Cody		1,325
"	Frontier	5,290+	2,750
"	Aspen (Mowry)	2,000±	1,070
"	Bear River	1,150	
	(Thermopolis)		325
L. Cretaceous	Gannett (Cloverly)	700	240-365
U. Jurassic	Stump	300	350
U. or M. Juras.	Twin Creek	970	475
L. Jurassic	Nugget	350	150
U. & M. Trias.	Ankareh	160	
L. Triassic	Thaynes	800 }	950
"	Woodside	650 }	
"	Dinwoody	700	225
Permian	Phosphoria	207	140±
Pennsylvanian	Tensleep	113	300±
"	Amsden	300±	400±
Mississippian	Madison-Brazer	1,500±	1,000±
Devonian	Darby	550	350
Ordovician	Bighorn	750	300-400
U. Cambrian	Boysen	215	102-181
M. Cambrian	Gros Ventre		
	Upper shale	160 }	539-578
	Death Canyon	200 }	
	Lower Shale	600 }	
"	Flathead		240±
MESOZOIC ROCKS	Total	13,070±	11,890±
PALEOZOIC ROCKS	Total	4,595±	3,589−

* Figures from Helen Foster (1946). This area is representative of the shelf zone of deposition; whereas, the Bradley Mountain area is in the trough zone of deposition.

** Hoback Basin area.

*** Names in parentheses refer to Gros Ventre area equivalents.

STRATIGRAPHY

Pre-Cambrian rocks

The high peaks of the Teton Range, about 20 miles north of the area of this paper, are composed of pre-Cambrian (probably Archean) crystalline rocks, and the Paleozoic sediments of the western back slope of the range lie on the crystalline complex. Since these same Paleozoic sediments crop out in the Greys River area, it seems reasonable to suppose that a similar crystalline complex underlies this area, although it is nowhere exposed at the surface.

Cambrian system

Flathead quartzite.- The Flathead quartzite of Middle Cambrian age was named by Peale in 1893 (p. 20) for exposures in Flathead Pass, in the northeast corner of the Threeforks quadrangle, Montana. It overlies the pre-Cambrian rocks almost wherever they are exposed in Montana and northwestern Wyoming. It is a white to tan, medium bedded orthoquartzite, occasionally with a basal conglomerate, overlain by the lower Gros Ventre shale. In the Teton Pass area, its thickness is about 250 feet. It is not exposed in the Bradley mountain area.

Gros Ventre formation.- The Gros Ventre formation of Middle Cambrian age was named by Blackwelder (1918, p. 417) in 1918. The type locality is on the west slope of Doubletop

Peak in the Gros Ventre Range, about 30 miles northeast of the area of this report. The formation has recently been measured by Wanless in the Snake River Canyon, near the narrows. (Unpublished manuscript)

The Gros Ventre formation is composed of a lower and an upper shale member, separated by a prominent limestone, the Death Canyon member, so named by Miller (1936, p. 12) from its exposure in Death Canyon in the Teton Range. The lower member comprises about 600 feet of green to gray paper shale interbedded with thin platy limestone. Foster (1946, p. 26) correlates this member with the Wolsey shale of the Yellowstone Park area. The Death Canyon member comprises about 200 feet of massive to platy limestone, usually a cliff former in contrast to the members above and below. It is exposed in the St. John thrust sheet where it forms inaccessible cliffs north of Greys River about 2/3 mile west of Squaw Flats, as well as in the Ferry Peak sheet on the Snake River. Foster correlates the Death Canyon Member with the Meagher limestone of Montana. The Upper Gros Ventre Shale, about 160 feet thick, is also composed of interbedded platy limestones and gray to greenish flaky shales. It is correlated with the Park shale of Montana by Foster and is exposed in the three westernmost thrust sheets of this area.

Boysen formation.- Earlier writers have called the upper Cambrian beds overlying the Gros Ventre formation the Gallatin limestone or Gallatin formation, but Deiss (1938, p. 1104) has pointed out that the name should not be used and has substituted the name Boysen formation, placing the type locality in the Wind River Canyon. There an unconformity is believed to separate the formation from the underlying shales.

The Boysen formation was measured in the Snake River Canyon by Wanless (unpublished manuscript), where it consists of about 215 feet of massive, light blue-gray limestone with characteristic buff mottlings and is exposed in all three thrust sheets west of the St John thrust.

Ordovician system

Bighorn dolomite.- The Bighorn dolomite was first described by N. H. Darton in 1904 (pp. 394-401), on the east side of the Bighorn mountains. He divided the formation into three members, the upper containing a Richmond fauna; the lower, a Trenton fauna. Miller considered all of the formation to be Richmond in age (1930, pp. 196-213), and Kirk (1933, p. 42) thought the lower part to be post-Trenton and pre-Maysville in age. Blackwelder collected a Bighorn fauna in the Gros Ventre Range which was considered to be Upper Ordovician by Ulrich but Middle Silurian by Weller and Kindle. (Blackwelder, 1913, pp. 174-179) Foster (1946, p. 35) suggests that the Bighorn in the Gros Ventre-Teton area may include more than one formation, only part of it being equivalent to the Bighorn in its type locality.

In the Snake River area, the formation as it has been recognized comprises 600 to 750 feet of massive light gray dolomite which weathers to a yellow-gray pitted surface and is a prominent cliff-former. Here the formation has been measured by Wanless (unpublished manuscript).

Silurian (?) system

Leigh formation.- The Leigh formation was first designated as an upper member of the Bighorn dolomite in 1913 by Blackwelder, when he submitted the name for U. S. G. S. approval. (Wilmarth, 1938, p. 1167) The type locality is Leigh Canyon on the west slope of the Teton Range, and Ulrich and Kirk have assigned a Richmond age to these beds. Blackwelder described the member as being very persistent, about 30 to 40 feet thick, and differing "from the rest of the Bighorn in being characterized by thin, dense, and brittle flaggy strata with smooth milk-white surfaces." (1918, p. 419)

Beds answering this description overlie unconformably the Bighorn formation in the Snake River Canyon area and have been called the Leigh member by earlier workers. However, fish plates discovered near the base of the Leigh beds in the Glory Mountain area have been identified as Upper Silurian or Lower Devonian by Case. (Foster, p. 35) If the age of the Bighorn dolomite is established as Upper Ordovician, the Leigh member should then become the Leigh formation and is tentatively so designated in this paper, although it has been mapped with the Bighorn dolomite. It may also be pointed out the the fauna from the Leigh beds in the Gros Ventre Range was placed in the Middle Silurian by Weller and Kindle (Blackwelder, 1913). Until more fossil evidence has been found, it is plain that the exact age of both the Bighorn dolomite and the overlying Leigh beds is doubtful.

Devonian system

<u>Darby formation</u>.- The Darby formation of Devonian age was named by Blackwelder in 1918 (p. 420) from exposures on Darby Creek on the west side of the Teton Range. In the Snake River canyon area, it overlies the Leigh formation with a probable disconformity and aggregates about 550 feet of thin interbedded limestones, dolomites, shales and siltstones. (Wanless, unpublished manuscript) Many of the limestones are petroliferous, and in the formation as a whole, the brown and yellowish brown colors which predominate appear to be due in part to carbonaceous matter.

Gardner (1944, p. 10), working in the Snake River Range to the north, divides the Darby into two members, an upper shale, siltstone and sandstone member, 210 feet thick, and a lower dark brown to black limestone and dolomite member, 360 feet thick. These divisions are recognizable in the Snake River Canyon section, the upper member being 190 feet thick.

Blackwelder (1918, p. 420) correlates the Darby formation with Peale's Three Forks shale plus the upper part of his Jefferson limestone in Montana. In southeastern Idaho, Mansfield also divides the Devonian into the Three Forks limestone and the Jefferson limestone. Since the Snake River area is between these two localities, it is possible that further study will extend these names into the area to subdivide the Darby beds.

Mississippian system

<u>Madison limestone</u>.- The Madison limestone of Lower Mississippian age is a widespread formation in Montana,

Wyoming, Idaho, and northern Utah. It was named by Peale (1893, p. 32) for an exposure in the Madison Range in the Threeforks quadrangle, Montana. The formation was recognized in the Teton Range by Horberg (1938, p. 16).

B. N. Moore measured the Madison and overlying, less fossiliferous Brazer formation in Hell Creek Canyon in the Snake River Range (Gardner, 1944, p. 9), where together they aggregate 1425 feet. In the Snake River Canyon area the writer estimates about 1,000 to 1,500 feet of Madison and Brazer. Both formations are prominent cliff formers. The Madison is a massive gray limestone, highly fossiliferous in many portions, brecciated or mottled in others. The Brazer is a blue-gray limestone, cherty in parts, and often with prominent calcite veins. It is less fossiliferous than the underlying Madison formation but contains several breccias, one of them usually at the top of the formation. Williams and Yolton (1945, p. 1150) have assigned the formation to a Middle and Upper Mississippian age.

Pennsylvanian system

<u>Amsden formation</u>.- In the Teton Range, the Pennsylvanian beds were placed in the Wells formation by Horberg (1938, p. 16). The type locality of the Wells formation is in Wells Canyon, Bannock County, Idaho, where it was named by Richards and Mansfield in 1912. (p. 689) However, Bachrach (1946) has since measured and described the Upper Mississippian

and Pennsylvanian section in the Teton, Snake River, Hoback, and Gros Ventre Ranges, and has assigned the "Wells" beds to the Amsden and Tensleep formations.

The Amsden formation was named by Darton in 1904, (pp. 394-401), the type locality being on the Amsden Branch of the Tongue River, west of Dayton. The prominent sandstone member near the base of the formation has been named the Darwin (or Dorwin of Wilmarth) sandstone member by Blackwelder (1918, p. 422) for an exposure on Darwin Peak in the Gros Ventre Range.

Only the upper member and part of the Darwin sandstone were measured by Bachrach (1946, pp. 13-17) on Red Creek near the Snake River canyon. Here the upper member contains 607 feet of interbedded limestone and shale. Many of the limestones are cherty, and the shales are red to gray. About 50 feet of the light gray quartzitic sandstone of the Darwin member was measured here. On South Indian Creek, the complete section was measured by Bachrach (pp. 9-13) and comprises 176 feet of upper Amsden, 130 feet of Darwin sandstone, and 11½ feet of lower Amsden. Bachrach is indefinite about the age of the Amsden, because of conflicting fossil evidence. It has generally been regarded as Pennsylvanian in age, but the lower part may be Upper Mississippian.

<u>Tensleep sandstone</u>.- The Tensleep sandstone was named by N. H. Darton (1904, pp. 394-401) for exposures in the walls of the lower canyon of Tensleep Creek, where it overlies the Amsden formation and underlies the Chugwater.

The name was brought into the Camp Davis area by Bachrach, who measured a section on Red Creek near the Snake River Canyon. She describes 113 feet of interbedded gray, pink and buff sandstones, which are quartzitic near the base; and white to light gray limestones, which are cherty near the top of the section. The South Indian Creek section aggregates 1115 feet in thickness. The Tensleep formation is placed in the Pennsylvanian by Love (1939, p. 29) from a fauna collected on Black Mountain in the Absaroka Range.

Permian system

Phosphoria formation.- The Phosphoria formation of Permian age was named by Richards and Mansfield (1912, pp. 683-689), from the type locality in Phosphoria Gulch, which joins Georgetown Canyon northwest of Meade Park, southeastern Idaho. They divided the formation into two members, a lower phosphatic shale member, and an upper cherty member, which they named the Rex chert for Rex Peak in the Crawford Mountains, east of Randolph, Utah. The name was extended into Wyoming by Blackwelder (1918).

Lillie Marie Krusekopf (personal communication) measured 207 feet of Phosphoria on the east flank of Bradley Mountain. Here the lower member consists of about 30 feet of limestone and dolomite interbedded with shales. Only the upper 5 or 10 feet are phosphatic at this locality. The Rex chert comprises about 270 feet of interbedded limestone or dolomite and chert, with one rather sandy unit. The section is complicated by a small fault which cuts off the base of the lower shale member, so the formation may be somewhat thicker.

Triassic system

<u>Dinwoody formation</u>.- The Dinwoody formation of Lower Triassic age was named by Blackwelder (1918, p. 425) from an exposure at Dinwoody Creek on the north slope of the Wind River Range. He defined it to include the gray shaly siltstones and shales, with thin brown limestones near the base, which extend from the Phosphoria formation below to the base of the red Chugwater formation above. Newell and Kummel (1942, p. 941) have lowered the Dinwoody-Chugwater boundary in the type locality to the top of the resistant siltstones, and thereby reduced the thickness of the formation to less than one half that originally measured. They believed the new boundary to be at a more consistent stratigraphic horizon than the varying one of color distinction.

Newell and Kummel (1942, pp. 976-977) measured the Dinwoody at MacDougals Pass in the Salt River Range, about 15 miles south of the area of this report, where it aggregated 735 feet of interbedded slabby gray siltstones and shales and silty limestones. Sections measured in the Wyoming range by Newell and Kummel and by Gray (1946) are very much thinner, and the rapid westward thickening of the Dinwoody would appear to be upheld in the Snake River Canyon region. The writer roughly estimates 650 or 700 feet of Dinwoody between the Phosphoria and the Woodside red beds on Bradley Mountain.

<u>Woodside shale</u>.- The Woodside shale of Lower Triassic age was named by Boutwell (1907, pp. 439-458) in the Park City District of Utah, where he described it as "fine-grained thinly bedded dark red shale. It Bears ripple marks, muc cracks and raindrop imprints." In the Camp Davis area, earlier writers, unable to separate the Woodside from the overlying Thaynes formation, mapped the two formations as a unit. Horberg (1938, p. 18) mapped these beds as the Ankareh formation; later writers, as the Woodside-Thaynes. Gray (1946, p. 26) proposes that they be mapped as Chugwater where not distinguished as separate formations. In the Snake River Canyon, however, the two formations are sufficiently distinct to be separated for mapping purposes on the basis of color and lithology, the red shales and siltstones of the Woodside lying between the buff Dinwoody and gray Thaynes.

The thickness of the Woodside shales in the Bradley Mountain area is estimated by the writer to be about 650 feet, a thickness consistent with Newell and Kummel's figures of 681 feet in Martin's Creek and 668 feet at MacDougal's Pass. Mansfield's Woodside formation (1927) aggregates a greater thickness, but the lower half of the formation as he employs the term is believed by Newell and Kummel (p. 940) to be the stratigraphic equivalent of the Dinwoody.

<u>Thaynes formation</u>.- The Thaynes formation of Lower Triassic age was named by Boutwell (1907, pp. 439-458) after exposures in Thaynes Canyon in the Park City district, Utah.

The formation was mapped by Mansfield (1927) in southeastern Idaho, and the name was extended into the Snake River area by Newell and Kummel (1942). On Martin Creek in the Wyoming Range, they measured an incomplete section of 527 feet of interbedded gray limestones and buff to maroon siltstones and shales. Gardner (1944, p. 8) measured 1000 feet of Thaynes, chiefly limestones, exposed on the ridge between Palisade and Trail Creeks on the west slope of the Snake River Range. This, apparently, was a complete section. In the Snake River Canyon region, a thickness of 750-800 feet has been estimated by the writer.

Ankareh formation.- The Ankareh formation was also named by Boutwell (1907, pp. 439-458), the type locality being Ankareh Ridge in Big Cottonwood Canyon, Park City district. In the same year, Veatch (1907) introduced the name Nugget sandstone (see below) for approximately the same beds plus those now assigned to the Nugget. Gale and Richards (1910, pp. 479-480) redefined the term Ankareh to include only the maroon to chocolate shaly beds between the massive Thaynes limestones and the dominantly sandy Nugget formation. The name is applied on that basis in this area.

Largely because of its stratigraphic position, the Ankareh is believed to be Middle to Upper Triassic in age, and is correlated by Gray (1946, p. 28) with Mansfield's Wood shale and Higham Grit. In the Fall Creek section, Gray (p. 12) measured 160 feet of Ankareh (?) beds. In the Snake River Canyon, however, no complete section is exposed.

Jurassic system

Nugget sandstone.- The Nugget sandstone was, as has been stated above, named by Veatch (1907, p. 56) but redefined by Gale and Richards (1910, p. 480). The type locality of Veatch is at Nugget Station on the Oregon Short Line. As redefined, the formation consists of massive red to white sandstone, often quartzitic, particularly in the regions where orogenic movements have occurred, where it characteristically forms resistent ridges flanked by black-weathering talus. In hand specimens, it is often undistinguishable from the Tensleep sandstones, but may be a little deeper red or less quartzitic than the latter.

On Fall Creek, on the east flank of the Snake River Range, the Nugget measured 350 feet (Gray, 1946, p. 12); and Gardner (1944, p. 8) reports 340 feet on the west flank of the Snake River Range. Fossil evidence is practically lacking, but stratigraphic evidence leads Mansfield (1927, p. 97) to place the Nugget in the Lower Jurassic.

Twin Creek formation.- The Twin Creek limestone was named by Veatch (1907, p. 56, 57) for exposures on Twin Creek in southwestern Wyoming, where the formation contains an abundant marine upper Jurassic fauna.

As mapped in the Bradley Mountain area, the Twin Creek includes all the interbedded gray limestones and maroon to gray shales between the green flagstones of the Stump formation and the sandstones of the Nugget, and so may also include beds placed by Gray (1946) in the Gypsum Springs (underlying the Twin Creek) and Preuss (overlying it) formations. Gray measured this group of beds on Fall Creek and reports an aggregate thickness of less than 800 feet. From the section mapped by Otton near Bailey Creek, the writer estimates a thickness of over 1000 feet. The formation is exposed at the core of the Little Greys anticline and in the overturned anticline beneath the Absaroka thrust on the east-west portion of Greys River, but in neither place was the writer able to estimate a thickness. Gardner (1944, p. 7) measured 970 feet of Twin Creek on the west flank of the Snake River Range.

Stump formation.- The Stump formation was named by Mansfield and Roundy (1916, pp. 76, 81) for Stump Peak at the head of Stump Creek, T. 6 S, R. 45 E, Boise Meridian, where a bed of marine upper Jurassic fossils is exposed near the base. The formation consists very largely of greenish gray fine-grained sandstones which weather readily into flagstones. Gardner measures 140 feet of Stump on the western slope of the Snake River Range. Otton (personal communication) estimates nearly 300 feet where the beds are exposed in the little Greys anticline.

Cretaceous system

Gannett group.- The Gannett group was named by Mansfield and Roundy (1916, pp. 76, 82-83) for Gannett Hills in the Wayan quadrangle on the Idaho-Wyoming border, where

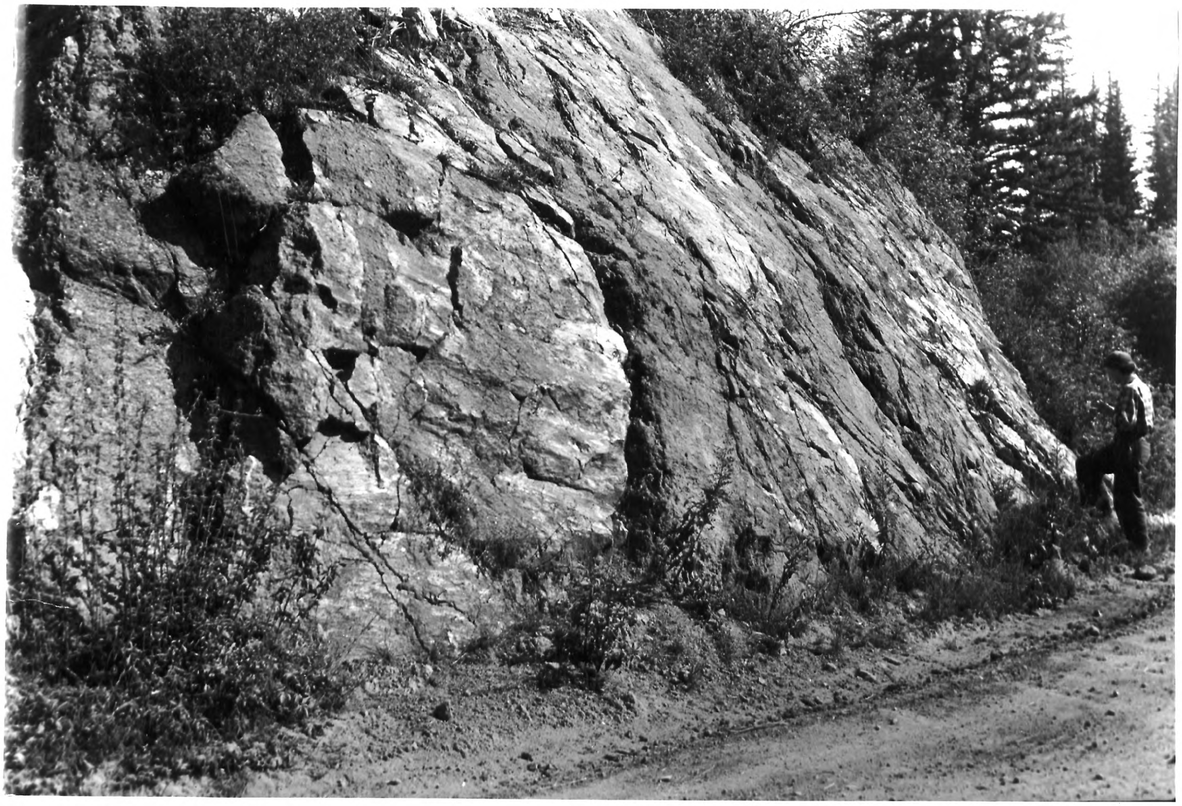


Plate V. Outcrop of the basal Gannett conglomerate (Ephraim?) on the Greys River road at Fire Trail Ridge, about a mile west of Little Greys fork.

it comprises five distinct subdivisions, top to bottom, the Tygee sandstone, Draney limestone, Belcher conglomerate, Peterson limestone, and Ephraim conglomerate. They term the group "probably Cretaceous" from rather limited fossil evidence.

Early writers in the camp area, unable to recognize the individual divisions of the group, mapped the Gannett as a unit. The writer has also mapped them as a unit in the Bradley Mountain area. However, it may be noted that in this area a massive reddish conglomerate, similar to the Ephraim conglomerate of Mansfield and Roundy (1916, p. 82), is found near the base of the Gannett. (See Plate V.) It has an estimated thickness of about 20 feet and forms a resistent ridge where it crops out near Fire Trail Creek on Greys River.

Gardner (1946, p. 7) found the Gannett group on the west slope of the Snake River Range to be 940 feet thick. On Little Greys River, the thickness is estimated at about 700 feet.

<u>Bear River formation</u>.- The Bear River formation was named by F. V. Hayden in 1869 (pp. 91, 92) for the coal-bearing strata near Bear River City, Wyoming. It was first believed to be of Tertiary age, but was later assigned to the Cretaceous by Hayden (1874, p. 1, 2).

In the Snake River Canyon area, Wanless (unpublished manuscript) has measured about 1150 feet of Bear River, comprising three members. The upper 650 feet is interbedded

Plate VI. Looking northwest from the crest of the Little Greys anticline. Sharp ridge is formed by the Bear River sandstone and shale dipping away from the camera on the west flank of the anticline.

fissile black to gray shale and thin brownish gray sandstones, with several thin fossiliferous limestones and a thin impure coal bed near the middle. This is underlain by 130 feet of massive gray sandstone which weathers brown and contains a few shaly partings near the base. The lowermost 370 feet is interbedded thin brown sandstones, gray shales and greenish siltstones, with shale predominating. (See plate VI.)

Aspen formation.- The Aspen formation was named by Veatch (1907, p. 64) for exposures recorded by Hayden, Bannister, Emmons, and King near Aspen station on the old Union Pacific Railroad line in southwestern Wyoming. Abundant fish scales proved it to be of Benton (Upper Cretaceous) age.

In the Snake River canyon area, the lower part of the Aspen consists of interbedded fissile black shales and arkosic "salt and pepper" sandstones. The upper part consists of shales and siltstones interbedded with vitrified tuff, called porcellainite by early workers. The porcellainite beds occur in a variety of colors, red, green, gray, and even black. Some varieties appear oolitic, although thin sections show the glass to be homogeneous. Whether the individual beds form continuous markers has yet to be determined. Dobrovolny (1940, p. 438) measured 1200 feet of Aspen in the Wyoming range and correlated it with the Mowry. At least 1500 to 2000 feet of Aspen is exposed in the Little Greys syncline.

Frontier formation.- The Frontier formation was named by W. C. Knight (1902, p. 721) for exposures near the town of Frontier in southwestern Wyoming. Veatch (1907, p. 69) places it in the Upper Cretaceous.

An incomplete section of the Frontier was measured by Ross and St John (1947, pp. 16-18) east of Deadman Mountain in the Wyoming Range, where it aggregated 5290 feet of massive gray to brown calcareous sandstone, conglomeratic at the base and containing several coal beds near the top of the section. It is conformable upon the underlying Aspen formation. In the Snake River Canyon area, the formation has been removed by erosion.

Eocene series

Hoback formation.- Although the Hoback formation is not found in the Snake River Canyon area, it is well exposed in its type locality, the Hoback Basin, about 20 miles east of the area of this report. (See plate III) Here its structural relations are important in dating the orogenies of the region. The formation was named by Eardley (1944). It is composed of dark gray shales, which weather light, interbedded with massive arkosic "salt and pepper" sandstones and a few impure freshwater limestones. Scattered conglomeratic lenses, probably representing river channel fillings, are also reported; and gastropods collected from the limestones were identified as Lower Eocene by Kellum (Eardley and Kellum, 1944). Eardley has estimated the formation to be 15,000 feet thick.

<u>Pass Peak formation</u>.- The Pass Peak formation is also exposed in the Hoback Basin, where it comprises about 2000 feet of coarse red and gray conglomerates, grading upward into sandstones and shales. It is dated as Middle Eocene by Eardley (1944), and is of importance in dating the late Laramide orogenies.

Miocene series

<u>Camp Davis formation</u>.- The Camp Davis formation was named by Eardley (1942, p. 1800) for exposures near Camp Davis, Wyoming, where it comprises a lower gray conglomerate, separated by fresh water limestone from an upper red or tan conglomerate. A fossil horse's tooth dates the formation as upper Miocene or lower Pliocene in age. In the type locality, it is believed to have accumulated on the downthrown block against the scarp of the Hoback fault, debris from the upthrown block finally burying the scarp.

A conglomerate of similar lithologic characteristics and structural relationships has been found to crop out along the west flank of the Snake River Range. Early workers (Veatch, 1907; Schultz, 1914) referred to this formation as the Almy conglomerate of Paleocene age; and Kirkham (1924, pp. 29-30) called it the Salt Lake formation and assigned it to the Pliocene. However, Enyert, McIntosh, and Bayless (Masters theses, University of Michigan, 1947) have recognized it as Camp Davis on the basis of similar lithology and structural relations to the type locality.

Enyert (1947, p. 17) describes four members observed in the Calamity Point area, beginning with the base of the formation. Unconformably overlying the Triassic in that area is the lower andesite member, a dark gray zeolitic hypersthene augite andesite sill (Mielenz, 1946, pp. 3-4) which has indurated the overlying sediments to a maximum distance of 8 feet from the contact. It is approximately 1200 feet thick. Above it lies a compacted silt member which consists of 800 feet of silts, clays, sands, and some tuffs, fused in places near the lower andesite contact. The upper andesite sill, of the same composition as that below, is 300 to 1000 feet thick and is overlain by a gray and then a tan conglomerate. The two conglomerates are separated by an unconformity, and the intrusion of the andesites is believed to predate the younger. The gray conglomerate is 200-300 feet thick and consists of rounded to sub-angular Madison-Brazer fragments. The upper conglomerate is about 3000 feet thick and composed of Madison-Brazer, Wells, Darby, Bighorn, and Boysen fragments.

In the Bradley Mountain area, only two small patches of Camp Davis formation were observed, one on the top of a small ridge on Squaw Creek, and the other at the easternmost edge of the area. In both localities, the formation consists of a gray limestone conglomerate, with sub- to well-rounded limestone pebbles, varying from 1 to 6 inches in diameter, cemented in a calcareous sandy matrix.

STRUCTURAL GEOLOGY

Laramide Structures

Regional description.- The Snake River - Hoback area lies along the eastern side of a Paleozoic-Mesozoic trough or geosyncline. During these two eras, about 44,000 feet of sediments accumulated in this sinking trough, while only 15,000 to 20,000 feet were being deposited in the shelf area to the east (Nelson and Church, 1943, p. 146). See the table of thicknesses, page 4 . The Hoback area lies at the eastern edge of this trough; the Snake River canyon area, near the center. Although the sediments thicken fairly abruptly between the two areas, similar structures are developed in both. In general, a succession of thrust sheets, with compression from the west, overlap one another from the western edge of the Hoback basin to west of the Idaho state line. (See plate III). Northwest of the Hoback basin, the Cache thrust represents yielding to compression from the northeast; and in the vicinity of Granite Creek this thrust may have overridden the easternmost of the thrusts from the west. The area under discussion lies just east of the Idaho state line.

Age of deformation.- Three stages of Laramide thrusting and folding are recognized in the Snake River - Hoback area. The thrust faults and related folds mapped in this paper probably belong to the first, or oldest, stage and, together with the Darby thrust (see Plate III) to the east, predate or provided sediments for the deposition of the Pinyon and Hoback formations. They deformed beds as young as the Frontier and may, therefore, be dated as late Upper Cretaceous or early Paleocene. The Pinyon conglomerate of Paleocene age may represent an early phase of this orogeny, although in northcentral Utah and southwestern Wyoming, the Darby and Absaroka thrusts are covered by the Almy conglomerate of Upper Paleocene age.

The second stage of deformation gave rise to the Jackson, Game, Cabin, and Clause thrusts, which are known to override the Hoback formation, compression again being from the west. These thrusts were followed by the deposition of the Middle Eocene Pass Peak conglomerate, which covers them in places. The second stage may therefore be dated as late Lower Eocene or early Upper Eocene.

The third stage is represented by the Grizzley thrust, which cuts the Pass Peak conglomerate. From relations exposed on Granite Creek, the Cache thrust, representing compression from the east, probably also took place at this time. The Grizzley thrust is displaced by the Hoback fault and so may be from late Upper Eocene to Upper Miocene in age.

<u>Absaroka thrust</u>.- The Absaroka thrust was first described by Peale in 1879 (p. 630) and later named by Veatch (1907, pp. 109-110) for its prominent trace along the eastern

Figure IV. Looking north from the divide at the head of Skull Creek. The trace of the Absaroka thrust is indicated by the black line. The Snake River Canyon road is in the middle distance.

slope of Absaroka Ridge in Uinta county, southwestern Wyoming. Veatch mapped the thrust as far south as the Utah-Wyoming border. Schultz (1914, pp. 66-67 and 36-41) traced the fault as far north as the Snake River Canyon, although his exact location of the trace across Greys River was somewhat in error. Horberg (1938, p. 28) and later Camp Davis workers have traced the fault well into the Snake River Range, making its total length well over 200 miles. Veatch (1914, p. 110) estimates the stratigraphic throw to be 20,000 feet in southwestern Wyoming. The throw decreases to the north and in the Bradley Mountain area is probably less than 10,000 feet. (See the geologic map and cross section, plates I and II) Mansfield (1927, p. 381) estimates its zone of displacement to be about 25 miles wide. (See Plate IV.)

Fire Trail thrust.- Beneath and possibly a branch of the Absaroka is a small thrust fault with a maximum of about 1,000 feet of stratigraphic throw. Its trace crosses Greys River just east of Fire Trail Creek, and so the name Fire Trail thrust has been tentatively assigned to it. The thrust may die out in an overturned anticline to the north somewhere beneath the Absaroka thrust sheet; and it has not been mapped south of Greys River.

St John thrust complex.- The St John thrust was named by Kirkham (1924, pp. 33-34) but he did not show it on his maps and stated that the details had yet to be worked out. On a tectonic map, Horberg (1938, fig. 7, p. 31) shows an unnamed fault, probably the St John, west of the Absaroka in the Snake River Canyon area. The writer finds that the

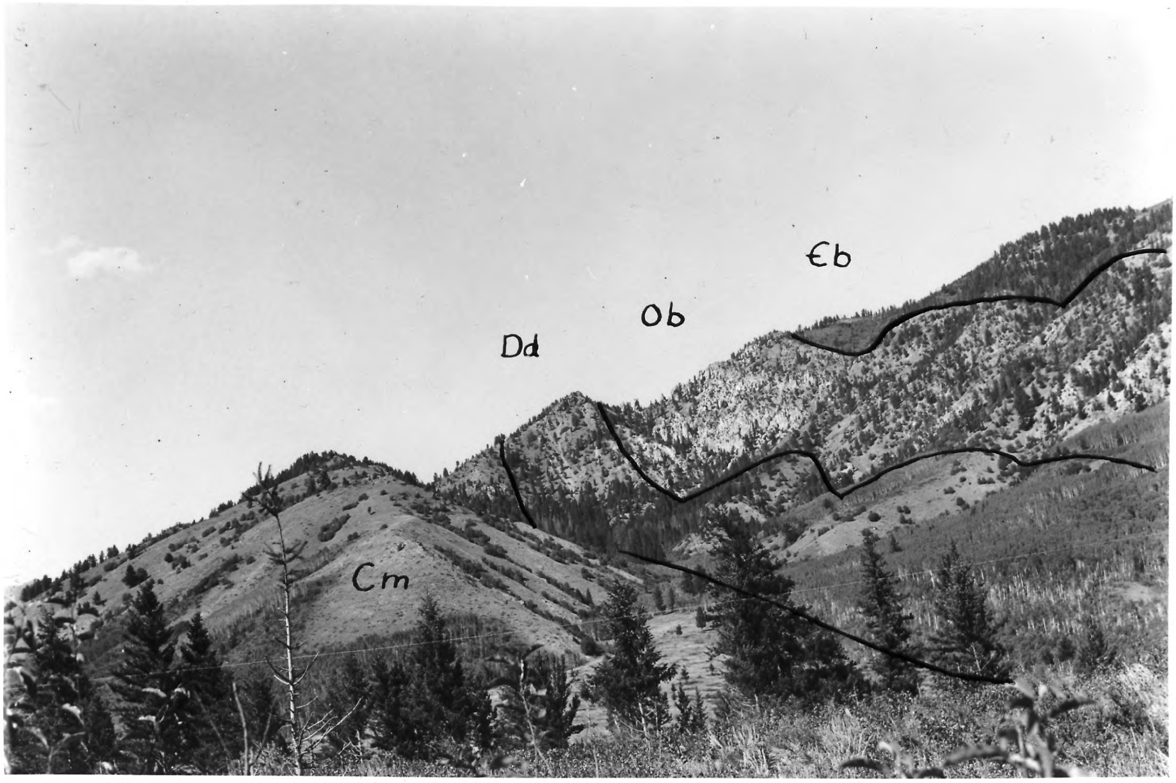


Plate IX. The Needle Peak thrust sheet as seen from the Greys River road, looking northward along the west slopes of the Bradley Mountain area.

fault is split into three thin sheets in the Bradley Mountain area and has therefore referred to it as the St John thrust complex. In the lowest sheet, Bighorn is thrust upon Madison; in the next above, Boysen on Bighorn; and in the upper sheet, Bighorn through Death Canyon on Bighorn. Although the thrust has not been mapped to the south it has been traced in the Snake River Range nearly 25 miles northwest of the Bradley Mountain area by Keenmon, Bayless, McIntosh, and Enyert (master's theses, 1947). In the Bradley Mountain area, its aggregate stratigraphic throw is estimated at about 1500 feet, but the dip slip is obviously much more.

<u>Ferry Peak and Needle Peak thrusts</u>.- In the Bradley Mountain area there is some doubt as to the relationship of the Ferry Peak and Needle Peak thrusts, so they will be discussed together. They were named by Bayless, McIntosh, and Enyert (Master's theses, 1947) in the Snake River Range, where they have been traced for nearly 20 miles along the western slopes. In the Bradley Mountain area they have an aggregate stratigraphic throw of nearly 3,000 feet. (See Plate IX)

Between Blowout Canyon and Indian Creek, the trace of the Ferry Peak thrust is covered by the Needle Peak thrust sheet. It is possible that this also happens in the vicinity of Grey's River; but if so, we would expect to find the Ferry Peak sheet at depth under the Needle Peak thrust. On the contrary, however, the Bighorn formation cropping out between the two faults appears to pinch out with depth as shown on the geologic cross section, plate II. Two explanations are possible. (1) The Needle Peak and Ferry Peak thrusts are two branches of the same thrust, movement along both of them having taken place at about the same time; or (2) the Needle Peak thrust has cut off the Ferry Peak thrust, and a definite age relationship between the two faults is thus established. Further mapping to the south may help in choosing the proper interpretation. It may also be pointed out that the interpretations discussed above may also be applied to the imbricate faults of the St. John thrust zone (see geologic cross section).

Little Greys syncline.- The Little Greys syncline lies in the Elk Mountain area to the east of Bradley Mountain. It was mapped as the Lazeart-Greys River syncline by Schultz (1914, p. 87, plate 1), who traced it as far south as the Afton Quadrangle. In the Elk Mountain area, it accounts for a wide outcrop of the Aspen beds. Minor irregularities in the broader structure may be revealed upon further study of the Aspen stratigraphy (Lucile Otton, personal communication). The long narrow ridges and valleys of the Bailey Creek region are formed by the east limb of this syncline, which is slightly steeper than the west limb. Together with the Little Greys anticline, it lies in the Darby thrust sheet.

Little Greys anticline.- The top of Elk Mountain and its northwesterly trending spur correspond very nearly to the crest of the Little Greys anticline. Prominent hogbacks to the east and west of this spur represent the resistent Bear River sandstones. Schultz mapped the anticline

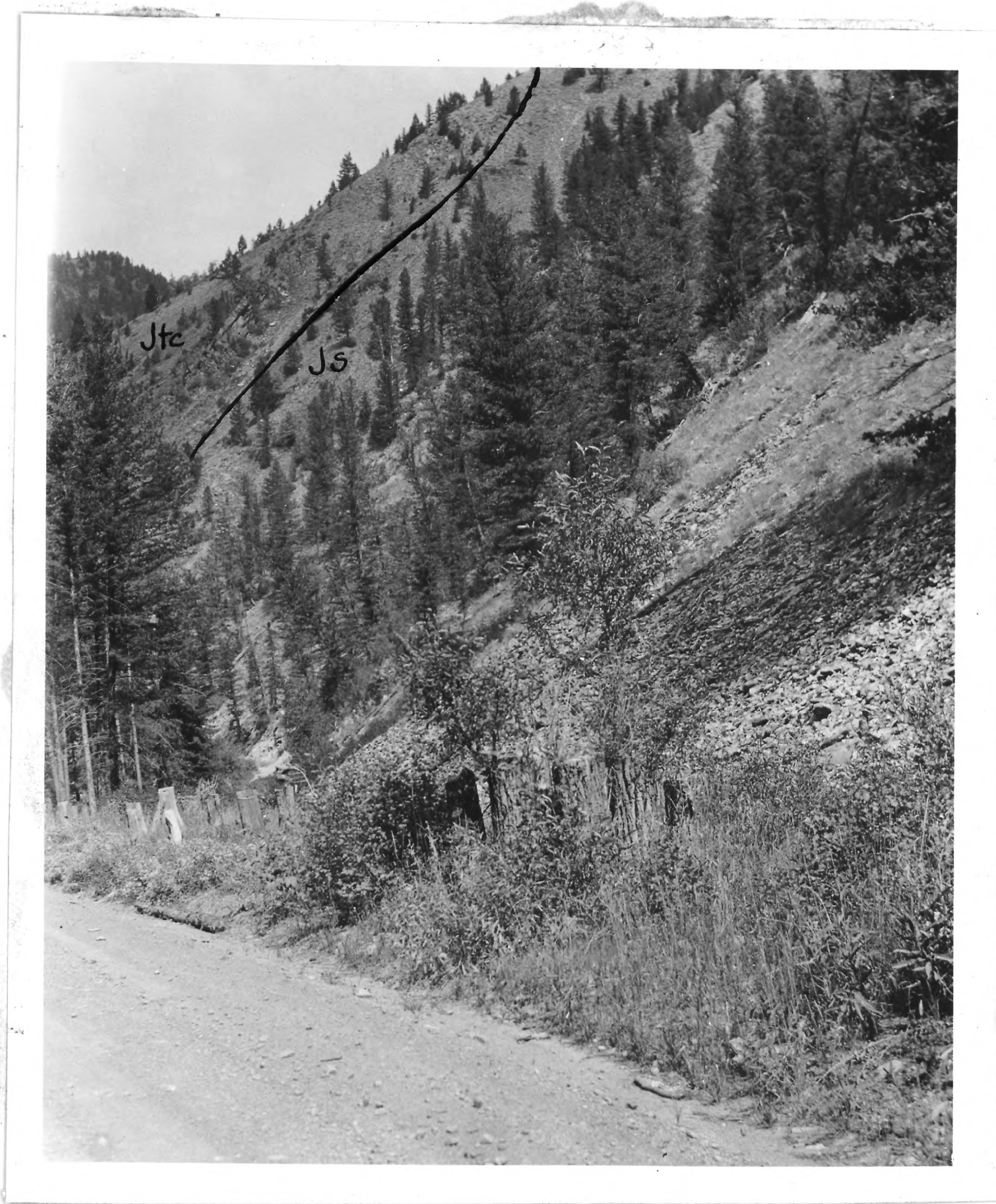
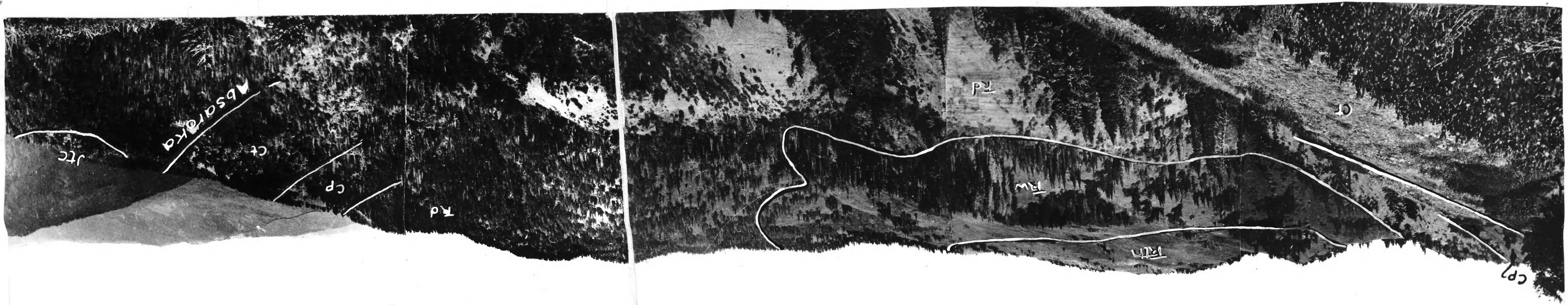


Plate VII. Looking west along the Stump-Twin Creek contact on the overturned east limb of the Fire Trail anticline. Greys River road in the foreground.

in 1914 but gave it no name. The structure is rather broad, with a small flexure near the crest and the east limb slightly steeper than the west one. It plunges to the north in the Elk Mountain area and, north of the Snake River, is covered by the Absaroka thrust sheet. Twin Creek beds are exposed in the core on both the Snake and Little Greys Rivers, and in the latter locality the structure has been unsuccessfully drilled for oil. It is reported that the Tensleep sandstone was the objective, but that the well bottomed in steeply inclined Triassic beds. It is not known to what depth the drillers penetrated.

Fire Trail anticline.- The Fire Trail thrust sheet is composed ov an overturned anticline, with the overturning toward the east. This anticline is well exposed along Greys River in the vicinity of Fire Trail creek and Higby Gulch. The beds of the overturned limb dip about 75° to the west; (Pl. VII) whereas the beds of the west limb dip somewhat less steeply. The Ankareh formation is exposed at the core of the anticline in Higby Gulch, where the Absaroka thrust sheet overlies the structure.

Bradley Mountain Syncline.- The Bradley Mountain syncline is in the Absaroka thrust sheet and forms the principal structure of that block in the Bradley Mountain area. It is a broad open fold with beds dipping 30 to 40° on its east limb, nearly horizontal for about a mile across its



Panorama

Plate VIII. Looking north to nearly east. Showing the Bradley Mountain syncline as seen from a strike ridge of its western limb.

axis plunges very slightly to the north, trending west of north. Ankareh beds (as well as residual Nugget debris at the summit of Bradley Mountain) are exposed in the core. A small flexure in the west limb is indicated by the width of the Madison outcrop west of Bradley Mountain. (See Plate VIII)

Mid-Tertiary faulting

Regional relations.- The Laramide thrusts and folds of western Wyoming are cut at an acute angle by a series of high angle normal faults, trending roughly north and south, of which the Grand Valley, Snake River, and Hoback faults are representative. The Hoback fault cuts the Grizzly thrust, as has been stated above, and is believed to have formed the trough in which the Camp Davis formation of Upper Miocene or Lower Pliocene age was deposited. Therefore, a Miocene age is postulated for this stage of high angle normal faulting in the region.

Grand Valley Fault.- What is probably the southern continuation of the Grand Valley Fault, mapped by Enyert, McIntosh, and Bayless along the western edge of the Snake River Range, is thought to extend along the western edge of the Salt River Range in the Bradley Mountain area. The existence of this fault is postulated because of the present topographic relief of the range and because of the small patches of Camp Davis formation to be found at the western edge of the range and as far eastward as Squaw Creek. The latter outcrop is at an elevation of about 6500 feet, and the present level of the Grand Valley floor is about 5500 feet. It is believed (Eardley, personal communication) that the sediments of the Camp Davis formation were derived from the upthrown block of the Grand Valley fault and accumulated to such thickness that they buried and lapped up over the original fault scarp, filling the tributary vallies some distance back from the fault scarp. Later erosion has developed the present topography, having removed nearly a thousand feet of sediments.

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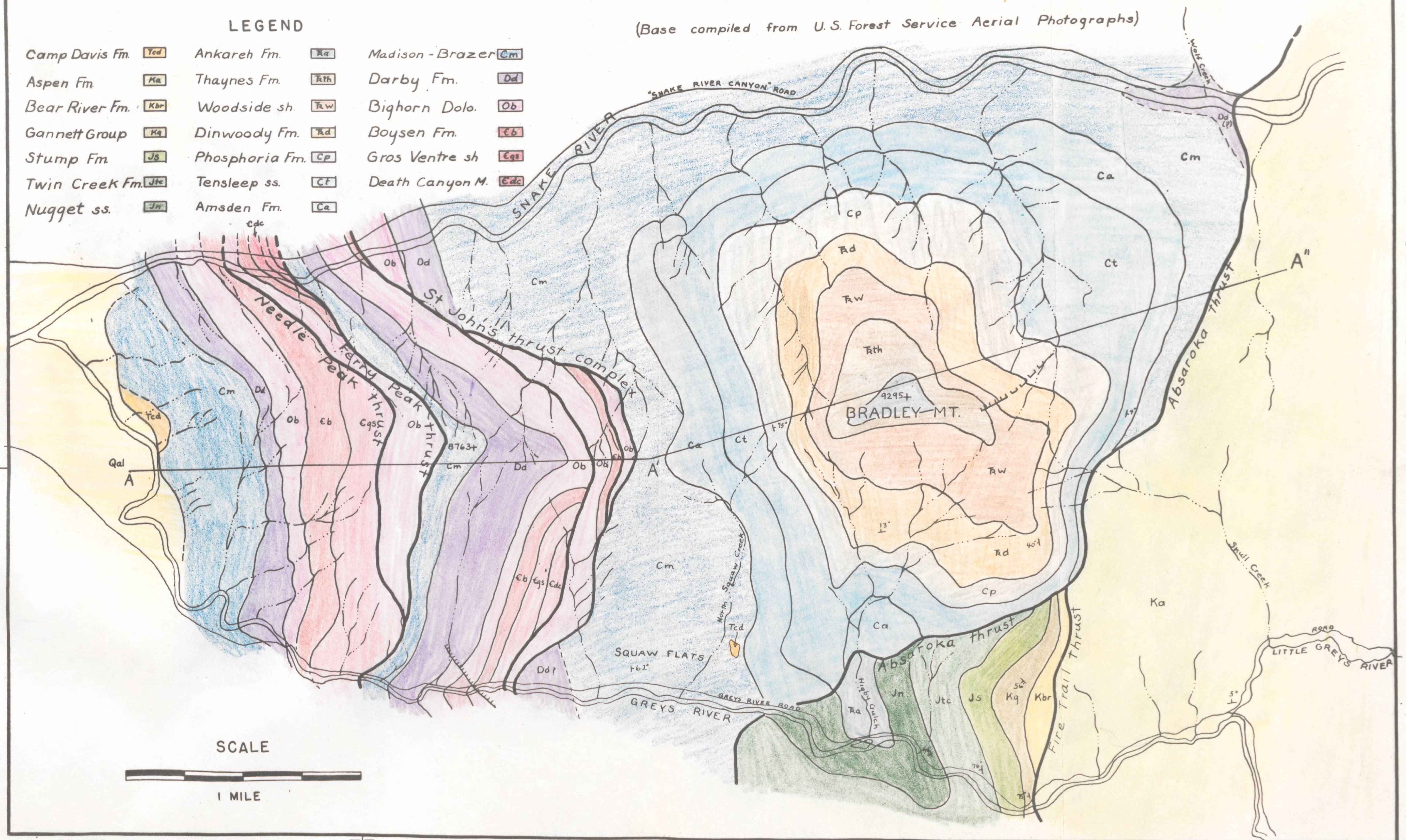
GEOLOGIC MAP OF THE

BRADLEY MOUNTAIN AREA, LINCOLN COUNTY, WYO.



TOWNSHIPS & SECTIONS UNSURVEYED

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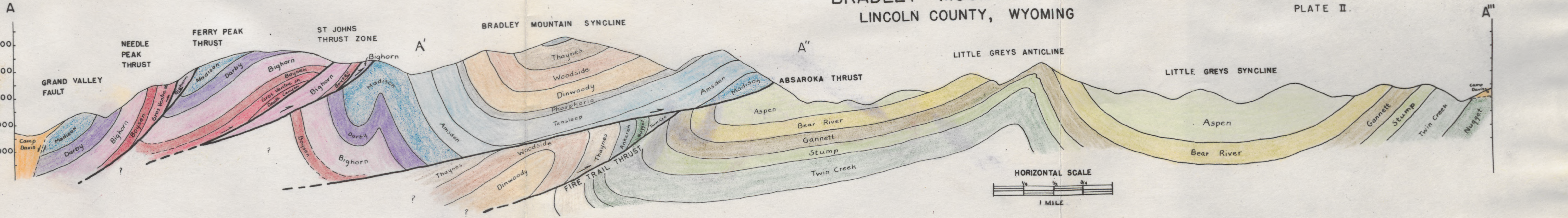
PLATE I

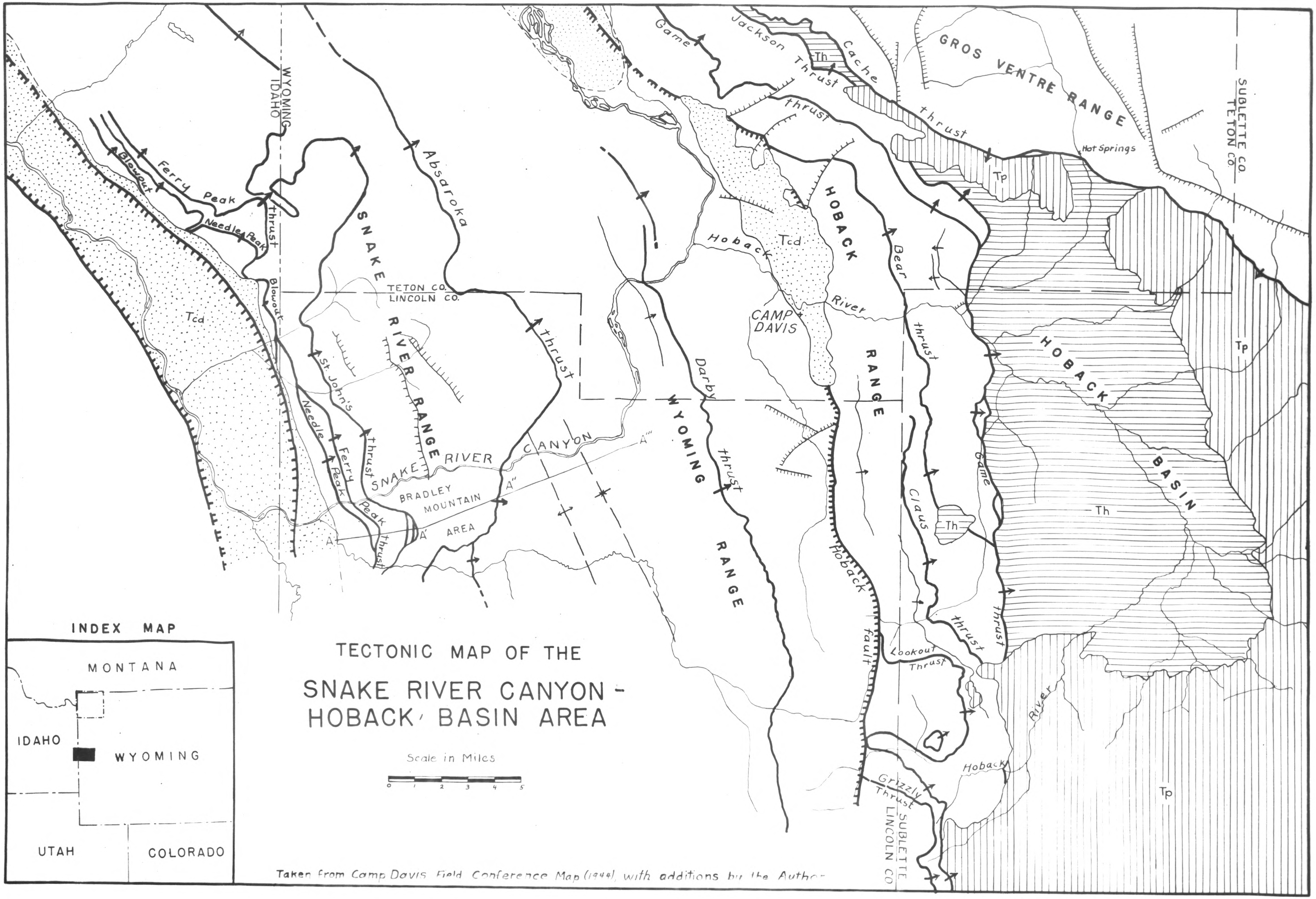
CROSS SECTION A-A'''

BRADLEY MOUNTAIN AREA

LINCOLN COUNTY, WYOMING

PLATE II.





TECTONIC MAP OF THE

SNAKE RIVER CANYON - HOBACK BASIN AREA

PLATE III