Laramide Geology of the Jackson Hole Area, Wyoming, and adjacent areas

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LARAMIDE GEOLOGY OF THE JACKSON HOLE AREA, WYOMING, AND ADJACENT AREAS

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INTRODUCTION

Geologic locale

Jackson Hole, Wyoming, is located in the midst of a group of mountain ranges. These ranges illustrate two types of mountains formed from sedimentary deposits of different thickness: a foreland type of mountain range formed from relatively thin sediments, and a geosynclinal type of range formed from very thick sediments. Two of the ranges discussed are of the foreland type and three are of the geosynclinal type. These ranges are unusual in that these two types of structure occur within a few miles of each other due to thrusting; thus comparisons can readily be made between them.

Purpose of paper

It is the purpose of this paper to discuss the Teton, Hoback, Gros Ventre, Snake River, and Big Hole ranges; their relation to neighboring ranges and to the general regional geology. This paper is also to be submitted as a master's thesis.

Acknowledgments

The author is especially grateful to Dr. A.J. Eardley for his suggestion of the problem and for his help in making the fault map of the region. Dr. Eugene H. Walker and John C. Bayless were also very helpful in providing transportation and offering suggestions concerning the geology of the Teton Basin area. Much appreciation is also due the author's field companions, E. Hollis Newcomb, Anne F. Wyman, and Richard V. Wyman, in the mapping of a portion of the northern Snake River Range.

STRATIGRAPHY

General description

The five mountain ranges under discussion lie in a transitional zone between a foreland facies on the east and a geosynclinal facies on the southwest. Because of the transition zone and also because of a series of major Laramide overthrusts which shortened the region, the ranges display a succession of beds whose thickness and lithology differs greatly in only a very short distance. The sections are complete except for the possible absence of Silurian. Due to the irregular development of the Rocky Mountain geosyncline the shelf area was deeper during Cretaceous time and received quantities of sediments that compare more favorably with those received farther to the west. The following table was taken from Wanless et al (1946) and represents columns measured in the various ranges during the past several years by the students and staff of Camp Davis, University of Michigan Rocky Mountain Field Station. No figures are given for the Big Hole Range, and Grayback Ridge is included to show the sequence. See Table 1.

Pre-Cretaceous stratigraphy

The following stratigraphic column is a generalized one for the Jackson Hole area and includes the Gros Ventre, Hoback, Teton, Snake River, and Big Hole ranges. The sources of data were Horberg(1938), Eardley et al (1944), Dobrovolny(1940), Kirkham(1924), Gardner(1944), and the author's own observations in the area. See Table 2.

Table 1

Age	Gros Ventre	Teton	Hoback	Grayback Ridge	Snake River
Cretaceous	9,816	Eroded	Eroded	5,200	4,800
Jurassic	925	450*	1,112	1,366	1,500
Triassic	1,270	xx	1,700	1,900	2,615
Permian	190	145	205	135	225
Pennsylvanian	750	750?	940	1,034	1,360
Mississippian	1,080	1,200	1,750	1,550?	1,800
Devonian	312	335	590	650?	850
Ordovician	350	280	130E	60E	730
Cambrian	853E	850	U	U	1,180E
Total in feet	15,546	4,010	6,427	11,915	15,060
Thickness exclusive of Cretaceous	5,730	4,010	6,427	6,715	10,260

* top eroded
xx not measured
U unexposed
E exposed

Table 2

Age	Formation Name	Thickness	Lithology
? Unconformity			
Upper Jurassic	Stump-Preuss formation	125'-190'	Grayish-green calcareous sandstone. Fine grained and thin bedded. Weathers brown. Contains marine fossils. At the base is a white to pink sandstone and red shale that is thin and poorly exposed.
	Twin Creek limestone	350'-725'	A dense, gray limestone and buff to gray shaly limestone which weathers into splintery fragments. Fossils are abundant. A basal limestone breccia is present.

Middle Jurassic	Gypsum Spring formation	50'	Red shale with interbedded limestone and gypsum in the eastern Gros Ventre Range.
~~ Unconformity ~~~			
Lower Jurassic	Nugget Sandstone	100'-350'	Buff to salmon colored, fine-grained sandstone. Locally quartzitic and massive. Aeolian cross-bedding is locally conspicuous.
~~ ? Unconformity ~~~			
Triassic	Woodside-Thaynes formation	100'-300'	Red shale, siltstone, and sandstone with interbedded dense gray limestone. Many ripple marks and mudcracks. Marine fossils in the Thaynes.
	Dinwoody formation	200'-250'	A thin-bedded, gray, calcareous sandstone which weathers with a brown stained surface. Calcareous shale and a massive fossiliferous limestone of the Thaynes type is present. Pelecypods are common in the limestone.
Permian	Phosphoria formation	50'-150'	Gray to black shales, brown sandstones and dolomites, some limestones and phosphate rock. Cherty limestone (Rex chert member) at the top. Fossil fish and marine invertebrates.
Pennsylvanian	Wells formation	300'-500'	White to pink quartzite. Red calcareous shales and massive gray limestone. Fossils are abundant in the limestone. The formation is often divided into the Amsden and Tensleep formations.
~~ Unconformity ~~~			

Mississippian	Madison-Brazer formation	800'-1000'	Blue-gray, dense limestone which is dominantly massive. Buff shaly limestone with red banding. Black chert nodules common in the Brazer. Fossils abundant.
Devonian	Darby(?) formation	150'-250'	Brownish-gray massive dolomite containing iron sulfides. Interbedded variegated shales. A few fossils are present.
Unconformity			
Ordovician	Bighorn dolomite	340'-385'	Massive, light gray to cream colored dolomite that weathers to a rough pitted surface. About 40 feet of thin-bedded, dense, brittle dolomite at the top forms the Leigh member. Fossils are rare. The formation is an important cliff former.
Unconformity			
Upper Cambrian	Gallatin limestone (Boysen)	180'-230'	Bluish-gray, mottled limestone which is oolitic in places. Weathers to a pitted surface. Fossils are rare.
Unconformity			
Middle Cambrian	Gros Ventre formation	600'-770'	Upper Park shale member is 200-300 feet thick. Death Canyon limestone is 285 feet thick in the Tetons and thins eastward. Forms a scarp. It is a fine-grained, dark gray, mottled with brown, and thin-bedded limestone. Often find trilobites poorly preserved in the partings. Lower Wolsey shale member is 200 feet thick.

Flathead quartzite	175'-260'	White to pink quartzite. Has oolitic hematite, ferruginous and glauconitic sandstone and shale in the upper portion. A well developed basal conglomerate is present. Fossils are rare.

~~~~~ Unconformity ~~~~~

Pre-Cambrian		Gneisses and schist intruded by granites and pegmatites. All cut by basic dikes.

Cretaceous formations

Gannett group. In the immediate Camp Davis area the Gannett consists of three divisions. The upper 250 feet is composed of gray shale and limestone. This is underlain by 55 feet of gray, massive, lithographic limestone. The lower 380 feet is light gray sandstones and red shale. Horberg(1938) notes only 250 feet of Gannett in the Teton Pass area. Kirkham(1924) measured 1750 feet of Gannett on Fall Creek, Idaho; and divided the group into five members: the Tygee sandstone at the top, 175 feet of Draney limestone, 225 feet of Bechler shale, 50 feet of Peterson limestone, and 360 feet of Ephraim conglomerate at the base. Gardner(1944) measured 940 feet of the Gannett between Trail and Palisade Creeks, Idaho, and divided it into four members. The Draney limestone is 245 feet of dark gray, nonresistant limestone with a thick shale bed. The Bechler shale is a covered interval of soft red shale. The Peterson limestone is dark gray, resistant, fresh water limestone with calcite veins. It is 125 feet thick. The Ephraim consists of red and purple shales, some
~~~~~

light gray, resistant, discontinuous quartzite beds, and a conglomerate which thickens to the west. This conglomerate is composed of red and purple limestone pebbles with many black chert pebbles of less than an inch in diameter. Lenticular beds of lavendar impure limestone and gray, thin-bedded nodular limestone also occur in the conglomerate. The Ephraim was deposited during Lower Cretaceous time following the rise of the Rocky Mountain Cordilleran geanticline in east-central Idaho and central Utah. The geanticline was the source of the pebbles (Richards, 1947).

Bear River formation. The Bear River consists of 800 to 970 feet of interbedded tan sandstones and hard, brittle, black shales overlain by salt and pepper sandstones. Conspicuous cross-bedding and lensing of the fairly coarse sandstones may indicate a flood plain origin (Dobrovolny, 1940). The sandstones are usually gray but weather tan and into large blocks. A fresh water fauna is present. Dobrovolny believes the formation to be Upper Cretaceous in age as does Veatch(1907); on the basis of fossil evidence LaRocque thinks the formation is early Upper Cretaceous in age. The Bear River lies unconformably on the Gannett.

Aspen formation. The Aspen varies in thickness from 590 feet to 1000 feet. The base of the formation is gray and black shales, and thick, massive, gray-green, salt and pepper sandstones. These basal sandstones are often calcareous and cross-bedded. Above are vitrified rhyolitic tuffs, interbedded with some tuffaceous siltstones. Megascopically the tuff beds resemble porcelain, but microscopically they consist of fine unweathered dust fragments of volcanic glass (Dobrovolny, 1940). Some of the tuff beds have the color bands parallel to the bedding. The formation in the Camp Davis area has more tuff than the Mowry farther north so it may have been deposited nearer the source. The Aspen may be distinguished from the Bear River, which it overlies conformably, by its tuff content. Some fish scales are found in the formation. It is Upper Cretaceous (Colorado) in age.

Frontier formation. The Frontier formation is 3000 feet of gray to buff arkosic sandstones and buff siltstones. It may be distinguished from the Bear River by the absence of tuff in beds although some of the silts contain reworked tuffaceous material. Bituminous to sub-bituminous coal is present throughout the formation (Woodruff, 1914, and Bergren, 1947). The bituminous coal has been worked quite extensively south and west of the Camp Davis area. The top of the formation has been eroded away throughout most of the region.

Tertiary formations

Hoback formation. The 15,000 feet of Hoback formation consists of interbedded gray sandstones and shales. There are several fresh water impure limestone beds and conglomerate lenses. There are no pre-Cambrian pebbles present in the conglomerate (Patton, 1947). The formation is dated as Latest Paleocene on the basis of a mammal tooth and jaw found in Dell Creek, 1947. The formation seems to be a direct result of early

Laramide thrusting. It lies unconformably on the Frontier.

Pass Peak conglomerate. This formation consists of 1000 to 5000 feet of coarse red and gray conglomerates that grade upward into sandstones and shales. It contains rounded pebbles redeposited from the Mt. Leidy region (Patton, 1947). It is Middle Eocene in age.

Camp Davis formation. The upper 2000 feet of the Camp Davis formation is red conglomerates. Below this is a 50 foot bed of fresh water limestone. At the base is 200 feet of gray conglomerate. The conglomerates contain pre-Cambrian pebbles from rocks exposed by faulting. Also present are rhyolitic and andesitic flows, breccias and tuffs. The formation has been dated as Lower Pliecene or Upper Miocene on the basis of a fossil horse tooth found in 1941 (Patton, 1947). It is equivalent to part of the Salt Lake formation of southeastern Idaho, which in places consists of fanglomerates (Boecherman, 1949).

MAJOR STRUCTURES

Foreland structures

The main foreland structural types are monoclinal flexures; broad, open, asymmetrical folds; high angle faults; and domelike upwarps. They trend mainly in a general northwesterly direction. Stresses acted upon the thin sedimentaries whose nature of yielding was determined by the earlier structure pattern of the underlying crystalline rocks. This earlier imposed structure pattern was block-like in character, so the resulting later pattern was similar. The larger blocks are often composite in character. Frequently the pre-Cambrian core is exposed because of the thin sedimentary cover.

The Tetons and Gros Ventre mountains are examples of foreland type structures. The Teton Range is a westward tilted, Tertiary fault block cut by numerous cross faults. The Gros Ventre Range is a series of asymmetrical anticlines or monoclines with their steep limb on the southwest. In several places the fold has broken and formed a thrust. The structural trends of the Gros Ventre's are thought to carry across Jackson Hole and reappear in the Tetons.

Geosynclinal structures

In the Rocky Mountain geosyncline the sediments reached a thickness of over 40,000 feet (Horberg, 1938). Even extensive faulting and thrusting has failed to expose the pre-Cambrian from under the sedimentaries, which are much more disrupted than they are in the foreland region since they have no shallow pre-Cambrians to absorb the shock. If there is any structural pattern present in the pre-Cambrian it is much too deeply buried to exert much influence.

The structure of the geosyncline is Appalachian in type. Large, shallow thrust sheets of great horizontal displacement with extensive folding on the upper plate are the common structures. These thrust sheets seem to be less competent than those of the foreland region, and there is much more folding and faulting associated with them (Van Dyke, 1947).

The Hoback and Snake River ranges are typical geosynclinal ranges. They are composed of more or less regular and linear folds which are compressed rather than open, and commonly overturned to the east (Nelson, 1942). Their general trend is north and south except where they touch against the southern end of the Tetons and are turned to the northwest. The general dip is to the southwest.

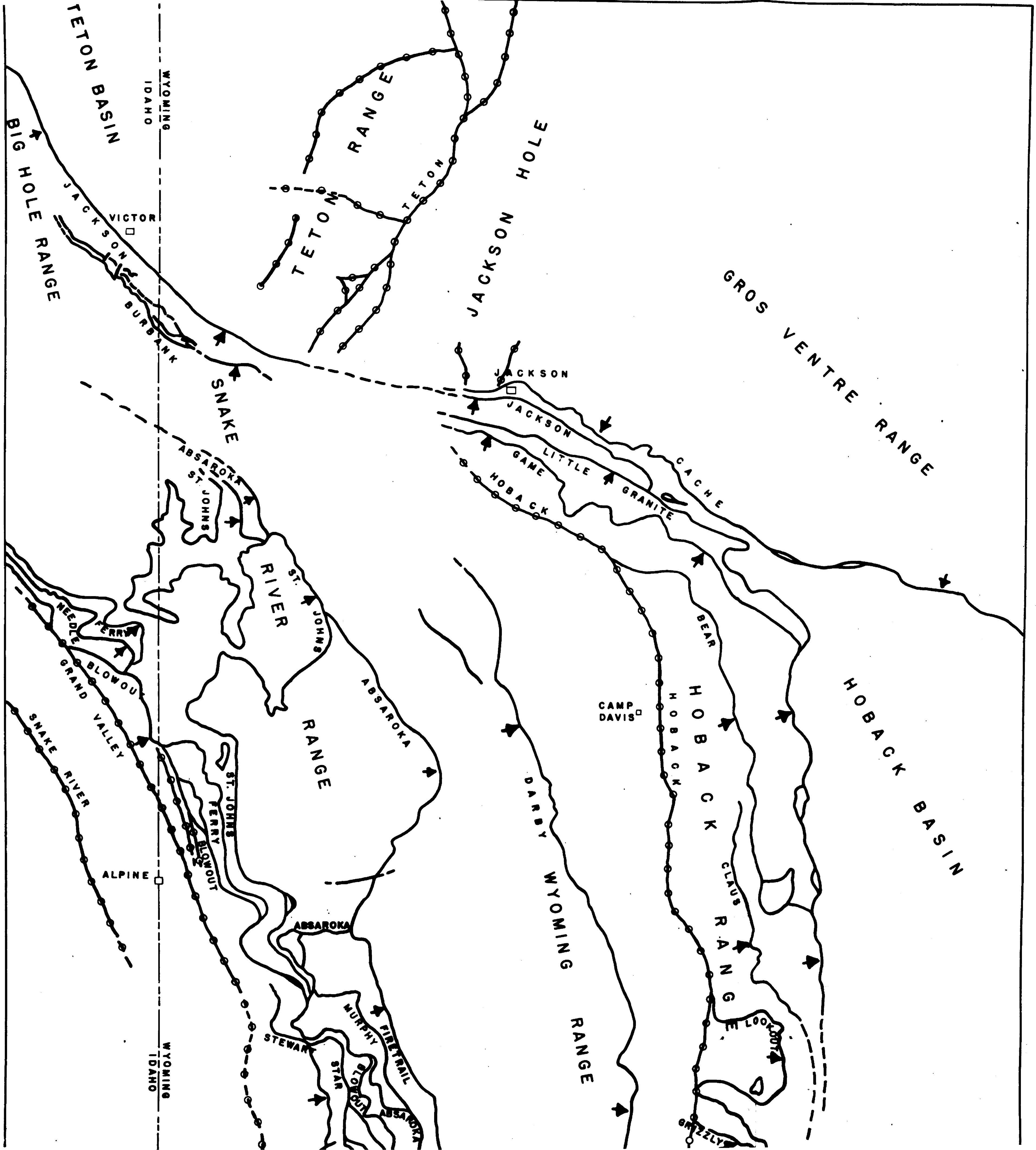
Major deformation

There were two periods of major deformation in the area: the Laramide orogeny and the Tertiary high angle faulting. Eardley divides the Laramide orogeny for the Rocky Mountain province as a whole into three periods: the early Laramide or Upper Cretaceous; the middle Laramide or Paleocene; and the late Laramide or Eocene. He does not include the Lower Cretaceous or even the early Upper Cretaceous in the Laramide orogeny. Some of the main Laramide thrusts were the Cache, Jackson, Absaroka, St. Johns, Darby, Game, and Little Granite.

Tertiary faulting includes the Teton fault, East and West Gros Ventre Buttes, Hoback fault, Grand Valley, and Snake River faults. See Plate One.

Plate 1

Major faults of the Jackson Hole area. The solid lines are Laramide thrusts. The circled lines are Tertiary high angle faults. Compiled from Eardley (unpublished map), Boeckerman (1949), and Horberg (1938).



TETON BASIN
BIG HOLE RANGE
WYOMING
IDAHO
TETON RANGE
TETON
JACKSON HOLE
VICTOR
JACKSON
BURBANK
SNAKE RIVER RANGE
JACKSON
GROS VENTRE RANGE
LITTLE GRANITE
GAME
HOBACK
CACHE
ABSAROKA
ST. JOHNS
NEEDLE
FERRY
BLOWOUT
GRAND VALLEY
SNAKE RIVER
BEAR
CAMP DAVIS
HOBACK RANGE
HOBACK BASIN
DARBY
WYOMING RANGE
ALPINE
CLAUS
MURPHY
FIRETRAIL
STEWART
STAR
LOOKOUT
GRIZZLY

STRUCTURES OF THE HOBACK RANGE

General description

The Hoback is a typical geosynclinal range. It is about 30 miles long and from four to six miles wide. In the northern part the peaks are about 10,000 feet high, with Hoback Peak reaching an altitude of 10,818 feet. South of this peak the range becomes less prominent and finally terminates rather abruptly against the north face of Thompson Plateau. The Hoback Range is composed of a series of southwestward dipping thrusts, a late normal fault along the southwestern edge of the range, and a series of parallel folds.

Kinds of structures

Jackson thrust. The Jackson thrust is the main eastern thrust of the Hoback Range and marks the northern edge of the geosyncline (Nelson, 1942). It appears from under the Tertiary lavas just east of Victor, Idaho, goes through the Teton Pass and along the northern edge of the Hoback Range. The fault has a general strike of N 60° W and a moderately steep dip to the southwest. Cambrian to Pennsylvanian beds have ridden over the Upper Cretaceous. Nelson(1942) has suggested that the thrust may have ridden on the Gros Ventre shales. The Jackson thrust rode out over the Paleocene Hoback formation and folded the beds. This thrusting post-dates the Hoback and pre-dates the Pass Peak, and is, therefore, probably Lower Eocene. The Pass Peak was then deposited and the thrust overrode it, and this favors the argument that the Jackson and Little Granite are separate thrusts because as the Little Granite thrust becomes larger and involves more beds toward the southeast the Pass Peak becomes gradually more horizontal and unaffected by thrusting. The Pass Peak and Hoback formations served as a footwall for the thrust and are affected by thrusting.

Nelson(1942) thinks that the Jackson and Little Granite thrusts are the same because the two thrusts are separated from each other by a distance of less than three miles, the faults strike in directions which should bring them together at depth, and the Little Granite is the outermost in the zone of thrusting just as the Jackson is. According to Bergren(1947) Eardley believes that Nelson and Church's Little Granite thrust is a continuation of the Jackson thrust. The southern extension of the Little Granite thrust is probably the Cliff Creek fault, which marks the eastern border of geosyncline deformation.

Game thrust. South of the Jackson and/or Little Granite thrust is the Game thrust. Nelson and Church (1943) state that the thrust is not traceable to its termination at the southeast because it is cut off by a high angle fault. Field evidence seems to indicate that it is a separate and independent structure which probably dies out only a short distance beyond its last exposure. The nearly vertical Mesozoic and Paleozoic beds of the Little Granite thrust pass under the Game thrust. Along much of the front the beds are flat-lying and the fault plane is essentially horizontal, but in the valley of Game Creek it suddenly dips to the southwest and goes below the surface. This change in dip appears to be due to drag along the Hoback fault. The Game thrust is considered the youngest of the three geosynclinal thrusts in the area by Van Dyke (1947). The Game, Bear, and perhaps the Little Granite faults make up the continuation of a thrust zone which is represented by the Cliff Creek fault on the east and the Jackson fault on the northern boundary of the geosyncline (Nelson, 1942).

Hoback fault. The Hoback fault is a Tertiary high angle normal fault in the northern Hobacks along the western margin. The fault has been traced from one mile south of Hoback Canyon to Game Creek. North of Game Creek the fault cannot be seen but the west front of the range has the appearance of a scarp, and the almost vertical north and northwest striking formations terminate abruptly to form the rim of Jackson Hole. These same beds with a similar strike reappear to the west in a small butte southwest of Jackson and indicate that the beds may have been faulted out (Nelson, 1942). The Hoback fault is partially covered by the Camp Davis formation so the fault may be Miocene (Ross and St. John, 1947). The forces that caused the Hoback fault may also be responsible for the faulting of the main Teton block.

Relation to early Tertiary deposits

During the Laramide orogeny great thrusts developed and the detritus was carried from the fault-produced uplands and laid down in the intermontane basins. The Hoback formation was the first to be deposited. Near the end of the Hoback deposition (latest Paleocene time) another movement occurred which folded the Hoback formation and also raised additional lands to erosion and caused the deposition of the Pass Peak formation. The Jackson thrust then caused the Hoback and Pass Peak formations to be deformed. The Little Granite thrust probably formed after the Jackson and was followed by the Game thrust. Later the Cache thrust and smaller associated faults from the northeast developed. Pre-Cambrian rocks were brought to the surface by these faults and fragments of them were deposited in the area as a new formation, the Camp Davis formation, along with reworked pebbles of the older formations. In the Hoback-Gros Ventre area the Camp Davis formation is very thin but it is horizontal and hasn't been affected by any folding or faulting in the area (Van Dyke, 1947).

STRUCTURES OF THE GROS VENTRE RANGE

General description

The Gros Ventre Range is part of the Middle Rocky Mountain Province. The range is about forty miles long and from fifteen to twenty miles wide. Its general trend is northwest-southeast. The crest of the range is almost uniform at 11,000 feet with a maximum of 12,200 feet at the eastern end (Schultz, 1914). The southern boundary of the range is determined mainly by the structure. The northern boundary is taken to be the Gros Ventre River. The western termination is abrupt and forms the eastern side of Jackson Hole, while the eastern side is a gentle dip slope that goes down into the valley of the Green River.

The range is part of the foreland area. Here, the basement crystallines were very important in controlling the later structures. The ranges tend to be blocky, often with pre-Cambrian exposed at the core. Folding is open; the southern border of the range is formed by a thrust-faulted monoclinal structure with a steep south limb. According to Van Dyke(1947) there are two groups of tectonic features in the Gros Ventre's; the dominating structures outlining or partly outlining the mountain blocks (early Laramide deformation), and the secondary structures superposed on the blocks and basins (late or post-Laramide deformation). The axes of the secondary elements are nearly parallel, north 40-50° west regardless of the major structure.

Kinds of structures

Cache thrust. The southwestern boundary of the Gros Ventre Range is formed by the Cache thrust. The fault plane dips northeast at 25° to 30° although in the Upper Horse Creek area the fault dips more than 45 (Patton, 1947). The strike is north 60° west. The formations involved are largely Carboniferous overlying upturned Frontier (Bergren, 1947). The horizontal displacement probably is rather small, not more than one and a half miles (Nelson, 1942). The Cache fault and anticline seem to continue to the west across Jackson Hole and terminate in the Taylor Mountain anticline of the Tetons. Its abrupt termination at the edge of the Hole may be due to a synclinal fold running across its strike or to a fault. There is evidence for either or to a combination. The fault extends southeastward and terminates agains the Skyline Trail fault which Eardley thinks is a continuation of the Cache thrust (Bergren, 1947). A small slice of Paleozoics resembles the beds of the Cache thrust under the pre-Cambrian of the Skyline Trail fault at its southeastern end and this suggests a minor movement in the thrust front over part of its trace.

Skyline Trail fault. Nelson and Church (1943) visualize trap door blocks or ramps replacing the Cache thrust as the southeastern boundary of the Gros Ventre Range. These ramp structures are defined as rectangular blocks with borders that are nearly straight lines in two prevailing directions. In this case the lines run east-west and north-south. They offer the Skyline Trail, Shoal Creek, and Elbow Mountain faults as examples of these ramp blocks. The maximum displacement is on the southwest corner. Pre-Cambrian rock has been thrust against the Mesozoic. Van Dyke (1947) thinks the fault trace along Cache Creek suggests a thrust fault with a changing angle of dip rather than a trap door block. The rocks are similar to those of the Cache thrust in sequence, attitude, and overturning. Lying on them are the almost horizontal beds brought in by the Skyline Trail thrust with the pre-Cambrian as a base and a normal sequence of formations overlying them (Van Dyke, 1947). Nelson (1942) has suggested that the Cache thrust may be a trap door structure in an advanced stage of development.

Horberg et al (1949) believes that the Shoal Creek, Elbow Mountain, as well as the Skyline Trail fault are ramp structures while Eardley believes that the entire southern border of the range is one thrust. The critical areas where the thrusts join is covered with glacial drift.

Relation to early Tertiary deposits

The Cache thrust cuts the Middle Eocene Pass Peak conglomerate, whereas the Jackson thrust cuts the Latest Paleocene Hoback formation but is overlapped by the Pass Peak. The Cache is younger, therefore, than the Jackson and related thrusts. This would indicate that the foreland structures developed later than the geosynclinal structures.

Relation to structures of the Hoback Range

The Cache Creek area is unique in that within ¼mile of each other lie two thrusts, dipping in opposite directions, one that caused these two faults probably did not occur simultaneously. The fronts of both faults have undoubtedly been stripped back but they probably did not overlap since no remnants of an overlap have been found.

As stated previously, there is evidence for a later date of foreland structure development. Bergren(1947) suggests three stages of folding and thrusting in the Cache Creek area:

> 1. Forces from the northeast caused folding of the Cache Creek monocline and its continuation, the Taylor Mountain anticline.
> 2. Then the Jackson overthrusting from the southwest.
> 3. Cache Creek monocline broke into the Cache thrust.

However, Nelson(1942) states that the foreland structures developed first along lines of earlier weakness in the pre-Cambrian and acted as a buttress against which the geosynclinal structures might be pushed. Evidence of this is seen in the abrupt change of strike assumed by the outermost of the geosynclinal structures where they touch on the southern ends of the Gros Ventre and Teton ranges. The major structures of the Hobacks trend north-south until they approach the southern Gros Ventres where they turn northwest. Also, the structures of the Snake River Range change from north-south to northwest where they meet the Teton structures. This buttressing effect may also be noticed in the series of discontinuous thrusts developed at the southern boundary of the Tetons and at the northeast end of the Hobacks where slicing occurred around the buttress instead of a single boundary. Horberg(1938) found that the Jackson thrust of the geosynclinal facies partially covers the south limb of the Taylor Mountain anticline; and that the footwall block of the Jackson fault west of Teton Pass is made up of beds ranging from Nugget to Upper Cretaceous, thus indicating that considerable erosion of the anticline took place prior to thrusting. This also indicates that the foreland structures developed somewhat earlier than the geosynclinal structures.

STRUCTURES OF THE TETON RANGE

General description

The Teton Range is one of the most impressive of the western ranges. The east front is a very steep scarp rising from the floor of Jackson Hole with no foothills at all. The peaks rise to a sharp maximum close to the eastern border and slope off gently to the west. The main body of the Tetons is composed of the pre-Cambrian with sedimentary rocks lapping up on the west. These sedimentaries appear in outcrop along the eastern front as one goes north and south from the maximum throw at the Grand Teton. Lava flows overlie the sedimentary beds on the west flank and extend around the northern end to connect with the flows of the Yellowstone region. The classic study of this region was by Horberg(1938) and unless otherwise credited information in the Teton section will be taken from Horberg.

Earlier structures and relation to structures of the Gros Ventre Range

Folding is present in the northern part of the Teton Range as two broad anticlines separated by a syncline containing Paleozoic sediments. The Moose Creek anticline is probably the westward continuation of the Nowlin Creek anticline of the northern Gros Ventre Range since they have the same orientation, are both monoclinal, and the youngest beds involved in both are Madison in age. It is broken by the Open Canyon fault, and to the east it passes into the Rendezvous Peak fault. The Taylor Mountain anticline apparently represents the continuation of the southern, main Gros Ventre anticline, and resembles the Moose Creek anticline in general trend, beds involved, and asymmetry. It has been modified by later faults, and the southern part of the fold has been partially covered by the overriding block of the Jackson thrust, from beneath which progressively younger beds crop out to the west.

It is thought that the Teton-Gros Ventre anticlines, which are typical of the foreland structures, were formed before the folds of the Snake River Range, which are of the geosynclinal type; and that the earlier structures acted as buttresses for the younger ones. These structures were apparently formed after the deposition of the Upper Cretaceous Mesaverde formation and before the deposition of the Pinyon.

Later structures

Teton fault. The Teton front is regarded as a scarp due to faulting. This fault is probably a high angle fault because of the linear base with a complete absence of foothills, the remarkably continuous front rising abruptly from the valley, the hanging valleys and the triangular facets at the ends of the short steep spurs. The average trend of the fault is N 10° W. The dip isn't known but it is probably somewhat over 40°

because the best preserved facets along the front have this average slope. The exposed scarp of the fault near Jenny Lake is over 7000 feet high but the true displacement is undoubtedly much more since this figure does not allow for stratigraphic throw or the amount of pre-Cambrian removed by erosion. The fault is considered Miocene in age (Nelson, 1942).

Buck Mountain fault. Viewed from the south or north it is obvious that the sedimentary beds would fail to clear the top of the range unless there were an abrupt flexure or fault behind the main crestline. Evidence points to the existence of the Buck Mountain fault. Behind Buck Mountain and South Teton the throw of the fault was not less than 1000 feet. To the southward the fault probably joins the Teton fault and is responsible for the reentrant in the front of the range at the mouth of Death Canyon. Northward the fault passes into the pre-Cambrian and dies out.

Table Mountain fault. The Table Mountain fault seems to be a hinge type fault with its maximum throw at the east front of the range. The alignment of Teton Canyon, the saddle south of Table Mountain, the col between Grand Teton and Middle Teton, and the steep south face of the Grand Teton suggests fault control, although direct evidence of faulting has not been noted in the pre-Cambrian. If this fault is assumed to continue to the east it may explain the superior elevation of the Grand Teton (elevation 13,747feet) which rises about 1000 feet higher than the summits to the south.

It dies out to the west.

Open Canyon and Rendezvous Peak faults. Two other faults of the hinge type are the Open Canyon fault and the Rendezvous Peak fault. The Open Canyon fault fades out on the south limb of the Moose Creek anticline, but the same trend of fracture is continued to the south by a fault along Coal Creek which ends in the south limb of Taylor Mountain anticline near the mouth of Coal Creek. The south limb of the Moose Creek anticline has been broken along a vertical east-west fault just south of Rendezvous Peak.

Fault blocks in Jackson Hole

There are several buttes resting on the floor of Jackson Hole. They appear to be similar in structure, stratigraphy, and origin. The East and West Gros Ventre Buttes are composed of folded and faulted Paleozoic strata with associated lava flows. The actual fault forming the eastern boundary of East Gros Ventre Butte has been uncovered and was found to be normal, striking N 30° E, and dipping 48° to the southeast. According to Scopel(1948) the surface lava flows lie on a surface of at least 700 feet relief which was not tilted after vulcanism. The lavas seem to lap down on the steep eastern slope so the eruptions must have post-dated the faulting which was probably Laramide. Also the lavas used some of the faults as avenues of escape. There is a small patch of Camp Davis conglomerate(?) against the base of the west butte lying in a valley which had been cut across the volcanic material.

This implies erosion after the igneous activity and before the conglomerate was deposited. Bergren(1947) suggests that faulting of the buttes took place before the main Teton fault since downwarping of the latter apparently initiated the deposition of the Camp Davis formation.

The events may be summarized as follows:

1. Laramide folding and faulting.

2. Great amount of erosion leaving the buttes as remnants of circumdenudation with at least 700 feet of relief.

3. Vulcanism with lavas and pyreclastics issuing from a few small vents and fissures. This was probably simultaneous with similar activity in the northern part of Jackson Hole in early or middle Miocene time.

4. Partial erosion of volcanic rock.

5. Deposition of Camp Davis formation initiated by Teton fault in late Miocene or early Pliocene.

6. Erosion.

7. Glaciation to form steep walls on both sides and around ends of buttes.

8. Alluviation in Bull Lake and Pinedale time.

STRUCTURES OF THE SNAKE RIVER RANGE

General description

The Snake River Range is bounded on the north by the Teton Basin and the Teton Mountains. On the east, south, and west it is delineated by the valley and canyon of the Snake River. The range exhibits typical geosynclinal structures: anticlines and synclines which have been broken along thrust faults. These structures are more or less parallel; the main structure lines run N 20° W in the southern part of the range but in the northern part along the Tetons the trend changes to N 60° W. The southward dipping Jackson fault forms the boundary for the termination of the structures at the Teton Pass area. The dip of the fault is probably not more than thirty degrees here. South of the Pass are complexly folded Mesozoic rocks while north of the Pass are gently dipping Paleozoics. No pre-Cambrian is exposed in the Snake River Range.

Northern Snake River Range

Introduction. During four weeks of the summer of 1948 the author assisted in the mapping of a portion of the northern Snake River Range. The area mapped was south of the road through Teton Pass; the eastern boundary was approximately two miles east of the Idaho-Wyoming state line. The southern boundary was the southern edge of the Driggs quadrangle map;

and the western edge was a line south from where Little Pine Creek enters the Teton Basin. The formations for the most part were dipping to the southwest, and there was a great deal of faulting within the formations themselves. Much volcanic material was encountered. An unnamed thrust fault was present, as well as the Jackson fault along the road over Teton Pass. East and west through the area, along the junction between Teton and Bonneville counties, Idaho, is a main drainage divide.

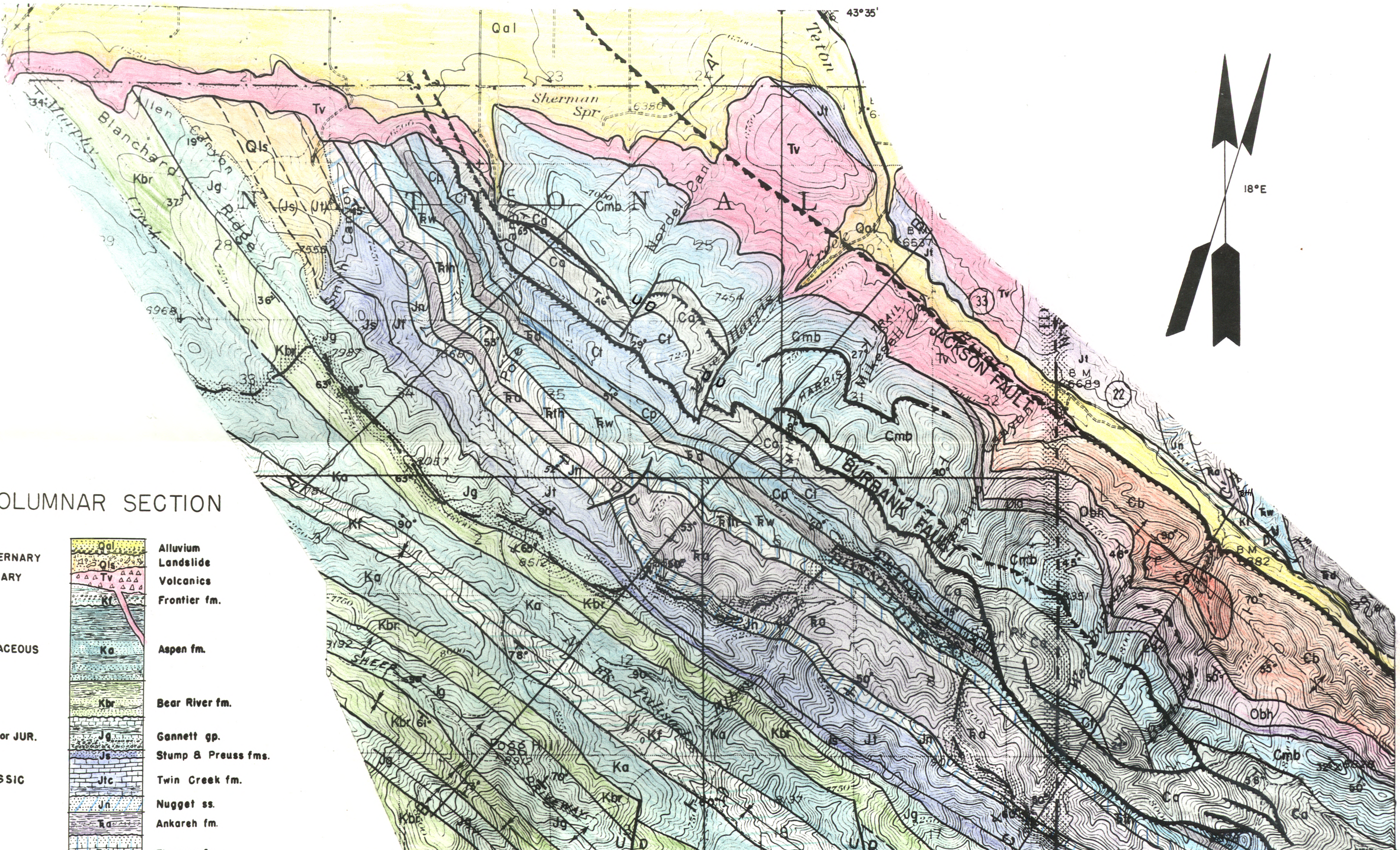
Stratigraphy. The formations encountered ranged in age from the Cambrian Gros Ventre formation to recent volcanics and alluvium. See Plate 2 for the stratigraphic column. Within the formations was evidence of faulting — breccias, slickensides, linear arrangment of springs, and the unusual thicknesses of the formations. Cliffs of Ephraim conglomerate were encountered in the northern part of the area. Anne F. Wyman (Wyman et al, 1949) has written up the stratigraphy of the region in detail. The northern front of the area was covered with Tertiary volcanics. The igneous rocks have been treated by E. Hollis Newcomb(Wyman et al, 1949).

Structure. The general structure of the area was southwestward steeply dipping beds. The beds for the most part were normal, but some were vertical, and the Nugget, Ankareh, Dinwoody, Twin Creek, and Bear River formations were overturned to the northeast in places. The gentlest dips were along the northern border. An anticline exposing the Gros Ventre formation was present near the mouth of Burbank Creek, and several anticlines and synclines were present in the Jurassic and Cretaceous rocks near the southern boundary of the area. Several normal faults were present within the area mapped.

The Jackson fault goes along the road through the Pass. On the northern side of the road are outcropping beds which are progressively younger to the west. The fault is covered by the Tertiary volcanics as the Teton Basin is approached; the fault probably extends under the Basin fill and the trace again appears at the surface in the Big Hole Range.

There is a major thrust fault that appears to have formed in several slices but it is probably the same fault throughout the area. This was named the Burbank thrust from the first discovery of it in Burbank Creek. Throughout most of its extent Amsden was faulted against Madison giving a relatively small stratigraphic throw. However, in the vicinity of Burbank Creek, Woodside was faulted against Amsden. The fault dips rather gently to the southwest. At one place the thrust front was cut by two normal faults forming a graben. The structure has been discussed in detail by Richard V. Wyman (Wyman et al, 1949).

From merely observing the western slope of the Teton Mountains Teton Basin could be thought of as a simple syncline filled with recent sediments. However, when one looks at the complexity of the Big Hole and northern Snake



Base - Driggs, Ida.-Wyo. quadrangle U.S.G.S.

COLUMNAR SECTION

QUATERNARY	Qal	Alluvium
	Qls	Landslide
TERTIARY	Tv	Volcanics
	Kf	Frontier fm.
CRETACEOUS	Ka	Aspen fm.
	Kbr	Bear River fm.
CRET. or JUR.	Jg	Gannett gp.
	Js	Stump & Preuss fms.
JURASSIC	Jtc	Twin Creek fm.
	Jn	Nugget ss.
	Tra	Ankareh fm.
	Trth	Thaynes fm.
TRIASSIC	Trw	Woodside fm.
	Trd	Dinwoody fm.
PERMIAN	Cp	Phosphoria fm.
PENNSYLVANIAN	Ct	Tensleep ss.
MISS. or PENN.	Ca	Amsden fm.
MISSISSIPPIAN	Cmb	Madison & Brazer ls.
DEVONIAN	Dld	Leigh & Darby fms.
ORDOVICIAN	Obh	Big Horn Dolomite
	Cb	Boysen ls.
CAMBRIAN	Cgv	Gros Ventre fm.

one inch = two thousand feet

GEOLOGY OF THE NORTHERN SNAKE RIVER RANGE

Mapped by R.V. Wyman, A.F. Wyman, E.H. Newcomb, and D.D. Marsik, July-Aug. 1948

miles

1 0 1 2

Thrust and Reverse Faults — upper plate

Normal faults — U/D

River ranges that bound the basin on the south and west, it is obvious that there must be considerable structure underneath it. There is a line of springs along the base of the Snake River Range where it joins the valley on the north. The stream formed from Warm Spring very seldom freezes in the winter (personal communication, Darld Marshall, local resident).

Southern Snake River Range

Absaroka fault. The Absaroka fault was first named by Veatch (1907). The fault has been traced for at least 200 miles, and the zone of displacement may exceed 25 miles (Mansfield, 1927). The stratigraphic throw may exceed 20,000 feet; the throw decreases to the north. The trace of the fault is sinuous (strike N 20° W) and the dip is low to the west. In the Red Creek area the thrust is five to eight miles wide and is composed of horizontal Paleozoic and Mesozoic formations which rest on the Darby. Near the fault trace the beds are upturned (Keenmon, 1948). The central crest of the range follows the thrust and the main peaks are just west of the fault. These peaks are bordered on the east by a lowland belt in the Cretaceous (Horberg, 1938). Madison has been thrust over Aspen along much of its trace (Oesterling, 1947). For a part of its length the Absaroka is covered by a part of the St. Johns thrust. Professor A.J. Eardley (class lecture) states that Paleocene beds are involved in the thrusting but that the thrust is overlain by lowermost Eocene. Thrusting there-

Creek where Amsden rests on the Aspen (Kirkham, 1924).

Palisade thrust complex. The Palisade thrust complex is composed of the Blowout Canyon, Needle Peak, and Ferry Peak thrusts. The Ferry thrust is the lowest and oldest of the three thrusts. It has been overridden by the other two thrusts. Boysen and Bighorn rest on the Madison giving a stratigraphic throw of 2300 feet. The dip is 20° to the southwest (McIntosh, 1947). The other two faults seem to originate from the Ferry at depth. The thrust was named from the exposures near Ferry Peak (Enyert, 1947). It rests on the St. Johns thrust.

Overlying the Ferry thrust is the Needle thrust. In the Calamity Point area of Idaho the Gros Ventre lies on Madison (Bastanchury, 1947), although along most of its trace Boysen lies over Bighorn. Its stratigraphic displacement is 400 feet (McIntosh, 1947). It dips 40° to 55° to the southwest (McIntosh, 1947). It rests on the Ferry thrust and is overlain by the Blowout thrust.

The Blowout thrust overlies both the Ferry and Needle thrust. Boysen formation lies on the Bighorn giving a stratigraphic throw of 400 feet (McIntosh, 1947). Part of the trace is covered by the Camp Davis formation. The dip is around 55°. The thrust is cut by the Tertiary Grand Valley fault.

STRUCTURES OF THE BIG HOLE RANGE

General description

Very little work has been done on the geology of the Big Hole Range. Woodruff(1914), Mansfield(1920), and Gardner(1944) have studied the region from the standpoint of the economic resources, mainly the coal and phosphate rock. Recently, Bayless(1948) has mapped the region as his doctoral problem.

The Big Hole Range is the northern extension of the Snake River Range from which it is separated on the south by Little Pine Creek. The general structure seems to be a continuation of the Snake River structures, viz.; southwest dipping beds, folding, and thrust faulting.

Stratigraphy

The east front of the range has been covered by lavas and conglomerates which appear from under the Teton Valley fill. The same lavas continue uninterrupted across the northern part of the range, and also cover much of the western side. The Cretaceous formations form most of the visible surface rock, with the Frontier formation dominating the outcrops. Triassic and Jurassic beds are also represented. The oldest formation present is the Madison.

The Frontier formation has been quite extensively mined for coal in the region, especially in the Horseshoe

Creek area. The coal is hard, black, and so badly broken that it usually comes out in fine pieces. It is bituminous but non-coking(Woodruff, 1914). Gardner(1944) has studied the phosphate reserves of the area and found them as good as those being mined in Montana. In the Phosphoria formation there are two bands of phosphatic material with the lower band being far the richer.

Structure

In the northern part of the range Horseshoe Creek has cut through the Horseshoe Creek anticline. This region has steep slopes trenched by narrow steep-sided valleys. The western boundary is a 1000 foot escarpment. Most of the rocks in the region dip steeply to the southwest. On the east side they are slightly inclined; on the west they are horizontal. In the southern part of the Horseshoe Creek area the rocks dip north and form a more complicated structure.

Bayless(1948) has mapped the continuation of the Jackson thrust in the Big Hole Range. In the range the fault is either present as three branches of different ages or overrode two earlier faults. The first thrust of the region occurred farthest to the east, with Triassic and Jurassic rocks overriding the Frontier. The rocks dip to the west along the front and a short distance back from the edge rise to form a syncline. There is a patch of Carboniferous rock in the southeastern corner of the thrust where it is overridden by the main thrust. Half a mile in front of this is a klippe of Carboniferous rock dipping in such a way that it could be considered the remnant of an anticlinal limb. However, it could also just as easily be a klippe from the main thrust although there is no evidence for overlap anywhere else.

Overriding this fault from the west is the second fault. This is Aspen formation over the Jurassic and Frontier. The beds dip to the west at the front of the thrust. The northern trace of the fault is lost under the volcanics, and the southern edge goes under the main thrust.

The main thrust swings west as it enters the area and then turns northwest rather sharply. The formations involved are Carboniferous over Frontier. The eastern trace is lost under the fill of the Teton Basin, and the northern trace disappears under the volcanics. (These faults occur to the northwest of Victor, Idaho, as extensions of the Jackson fault, and are just off the map, Plate 1).

REGIONAL HISTORY AND SEQUENCE OF EVENTS

Nelson and Church(1943) state convincing evidence for their theory that the foreland structures of the Gros Ventre and Teton ranges were formed before the geosynclinal structures. Their reasons are: overriding of the Taylor Mountain anticline by the Jackson thrust (the Taylor Mountain anticline of the Tetons is believed related to the folding in the Gros Ventre Range); the abrupt change in general geosynclinal strike as the northern edge of the geosyncline is approached; and the buttressing effect and slicing that occurred around the southern end of the Tetons and Gros Ventres instead of a single thrust boundary. However, it would seem that when the deeper geosynclinal sediments were pushed against the shallower shelf zone with a pre-Cambrian basement they would be deformed regardless of whether the Tetons and Gros Ventres were present as ranges. Also, the Gros Ventre-Teton anticlines may have been formed first (Bergren, 1947) but resisted thrusting until after the geosynclinal thrusts had developed.

Many of the Camp Davis geologists believe that the geosynclinal structures were formed earlier. Van Dyke (1947) states that the Jackson and Little Granite thrusts are folded along their margins whereas the later Game thrust is flat-lying. He also says that this folding was due to the fact that they were already there when the foreland thrusts developed and were deformed by them. However, in general the geosynclinal thrusts are considered less competent and would tend to buckle during orogeny as well as after. The foreland sheets were not folded but are simple thrust sheets. On the basis of the Tertiary formations the foreland structures seem to be later.

The Absaroka and Darby thrust were probably the first faults formed in the region. The Paleocene beds are involved in the thrusting, and the fault traces are obscured in part by the lowermost Eocene beds. Thrusting probably occurred in the Late Paleocene. These were followed by the St. Johns thrust and the Palisades complex. The next series of thrusts began with the Jackson thrust of the Hoback Range. This was followed by the Little Granite, Game, Cabin and Clause thrusts of Lower Eocene or post-Hoback - pre-Pass Peak time. Then, in this sequence of events Van Dyke (1947) would include the Skyline Trail fault as Middle Eocene? . The Cache and Grizzly thrusts of Upper Eocene or Lower Miocene time cut the Pass Peak formation and are overlapped by the Camp Davis formation.

Following these thrusts came a series of Miocene rift faults (Foster, 1947). The Hoback fault is pre-Camp Davis or Miocene in age. This was followed by the faulting of the Gros Ventre Buttes?. Then the Tetons were faulted along with the Grand Valley and Snake River faults.

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