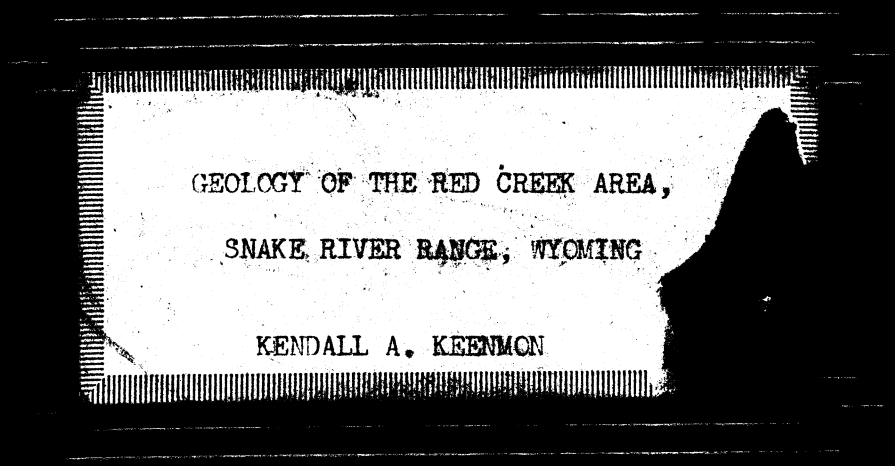

GEOLOGY OF THE RED CREEK AREA, SNAKE RIVER RANGE, WYOMING

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ABSTRACT

The Red Creek area, Snake River Range, Wyoming, is located immediately east of the Idaho-Wyoming border and is approximately 60 miles south of Yellowstone National Park. The formations cropping out in the area range in age from the middle Cambrian Gros Ventre formation to the Jurassic Twin Creek formation. The St. John, Ferry Peak, and Needle Peak thrust faults of Laramide age are traceable through the Red Creek area. These faults may be branches of the Absaroka thrust fault, which parallel the eastern boundary of the area of this paper. A small stock of diorite on North Red Peak may be post-Absaroka thrusting in age, but there are no field relations to indicate its true age. Three stages of deformation in the Laramide orogeny are recognized. The first is Paleocene in age, the second is post-lower Eocene in age and the third is middle to upper Eocene in age.

SCALE IN MILES

0 25 50 75 100

INDEX MAP

Red Creek Area, Snake River Range, Wyoming

INTRODUCTION

Location of Area

The Red Creek area, Snake River Range, Wyoming is a portion of the Snake River Range which runs northwest-southeast from central Eastern Idaho into Western Wyoming (See index map - plate 1). Yellowstone National Park lies some 60 miles to the north of the area. The Teton Range and Jackson Hole lie between the Park's southern boundary and the Snake River Range. The area is bounded on the north by the Teton Range; on the northeast by the Hoback and Gros Ventre Ranges, which trend essentially parallel to the Snake River Range; on the south by the Salt Creek and Wyoming Ranges; and on the west by the Grand Valley of the Snake River and the Caribou Range, which are in Idaho. The Grand Canyon of the Snake River, Wyoming is traversed by a two lane gravel road which connects Alpine, Idaho with U. S. Highway 187 about 10 miles south of Jackson, Wyoming.

The Red Creek area, Snake River Range, Wyoming is included on the Jackson topographic quadrangle. The specific area mapped lies to the north of the Grand Canyon of the Snake River, between Wolf Creek on the east and Ferry Peak Ridge on the west. The northern boundary of the area is defined by a line drawn from a point on

the south branch of Indian Creek immediately north of Ferry Peak eastward to North Red Peak and then southeastward to the West Branch of Wolf Creek, and finally to Wolf Creek, which is the eastern boundary.

The highest peaks of the area are Wolf Mountain, elevation 9491 feet, located in the extreme eastern part of the area, and the two Red Peaks in the northeastern part of the area mapped. On the U. S. G. S. Jackson topographic quadrangle map, two Red Peaks are shown within the area mapped. To eliminate confusion it is here proposed to call the northernmost of these two peaks, whose elevation is 9861 feet, North Red Peak, and the southernmost of these two peaks, whose elevation is 9790 feet, South Red Peak.

Purpose of study

The purpose of this report is to describe the stratigraphy and structural geology of the Red Creek area of Wyoming and to discuss its relationship to the larger pattern of Laramide deformation that has been worked out by A. J. Eardley and other members of the Camp Davis staff. The report includes a brief petrographic description of the diorites of the Red Creek stock and the andesite of the West Wolf Creek sill.

This report also is offered as a Master's thesis in geology. The field work upon which this report is based was part of a larger project of mapping by members of the faculty and students of Camp Davis, the Rocky Mountain Field Station of the University of Michigan, which is located near Jackson, Wyoming.

Acknowledgments

The field work for this paper was done during the month of August, 1946. Camp Davis was used as a base camp for part of the work, and then a field camp was established on upper Wolf Creek, below Wolf Mountain for convenience in mapping the upper areas which are more remotely located from the road. A. J. Eardley, Professor of Geology, University of Michigan, was in charge of the field work and of the writing of the report. H. R. Wanless, Professor of Geology, University of Illinois, made many helpful suggestions. E. W. Heinrich, Professor of Mineralogy, assisted greatly in the identification of thin sections.

STRATIGRAPHY

General

The following stratigraphic column (table 1) is a complete section for the surrounding area, which includes the Snake River Range, the Teton Range, and the Hoback Range. The formations cropping out in the Red Creek area range from the middle Cambrian Gros Ventre formation to the middle to upper Jurassic Twin Creek formation.

Pre-Cambrian rocks

Pre-Cambrian rocks are nowhere exposed in the area mapped, but they crop out in the Teton Range, 40 miles to the north, and form the core of the range. They are composed of steeply dipping gneisses and schists, which have been intruded by pegmatite, granite, and basic dikes (Horberg, 1938, p. 13).

Cambrian system

Flathead quartzite.-- The Flathead quartzite crops out nowhere in the area mapped, but it is very close to the surface in certain places where the Gros Ventre formation is deeply eroded. The Flathead quartzite is made up of white to tan, medium bedded, ortho-quartzites. A

Table 1.-- Generalized Stratigraphic Column of Western Wyoming

Age	Formation	Thickness in feet
Upper Miocene	Camp Davis conglomerate	6,300
Middle Eocene	Pass Peak conglomerate	3,000
Lower Eocene	Hoback formation	15,000
Upper Cretaceous	Frontier formation	5,000
Upper Cretaceous	Aspen formation	2,000
Lower Cretaceous	Bear River formation	900
Lower Cretaceous	Gannett formation	700
Upper Jurassic	Stump sandstone	110
Upper Jurassic	Preuss sandstone	120
Middle to Upper Jurassic	Twin Creek formation	600
Middle Jurassic	Gypsum Spring formation	170
Lower Jurassic	Nugget sandstone	350
Middle to Upper Triassic	Ankareh formation	400
Lower Triassic	Thaynes formation	950
Lower Triassic	Woodside formation	700
Lower Triassic	Dinwoody formation	630
Permian	Phosphoria	240
Pennsylvanian	Tensleep sandstone	800
Upper Mississippian to Lower Pennsylvanian	Amsden formation	710
Upper Mississippian	Brazer limestone	250
Lower Mississippian	Madison limestone	850
Devonian (?)	Darby formation	550
Devonian (?)	Leigh formation	40
Ordovician	Bighorn dolomite	730
Upper Cambrian	Boysen formation	210
Middle Cambrian	Gros Ventre formation	965
Middle Cambrian	Flathead quartzite	175
Pre-Cambrian	Schists and Gneisses	Unknown

well developed basal conglomerate rests upon the eroded pre-Cambrian basement complex in the Teton Mountains (Horberg, 1938, p. 13). There the thickness of the Flathead quartzite is 175 feet. The strata are divisible into two parts - the lower, consisting of conglomerate, sandstone, and ortho-quartzite 140 feet thick; and the upper being composed of 35 feet of ferruginous sandstone, oolitic hematite, and green, sandy shale. Horberg reports further that there is no perceptible stratigraphic break at the top of the formation, and that the base of the lowest thick shale was taken as the top of the Flathead formation.

Peale (1893, pp. 20-21) applied the formational name to strata cropping out in Flathead Pass in the northeastern corner of the Three Forks quadrangle of Montana. The rocks were composed of 125 feet of sandstone or quartzite, which had interbedded, reddish-brown siltstones. The Flathead quartzite is middle Cambrian in age.

Gros Ventre formation.-- The Gros Ventre formation is found in the Palisades thrust sheet and it crops out approximately one half mile west of the Narrows on the Snake River. The Gros Ventre formation is composed of three members: a lower member of red and green shales; the middle Death Canyon limestone member; and an upper

green shale. The lower shale member is a combination of red and green chloritic, glauconitic, and hematitic shales, which Miller (1936, pp. 119-120) reported to be 100 feet thick, in the Teton Range area. The Death Canyon limestone member was named by Miller (1936, pp. 119-120), who described it at the head of Death Canyon in the Teton Range where it is 285 feet thick. It is composed of a bluish-gray, thin-bedded to massive, coarse grained, cliff forming limestone, with irregular yellow partings and mottlings. The upper member is made up of 200 to 300 feet of green, non-resistant shales, with a gray to yellowish gray limestone and an interformational breccia.

Gardner (1944, p. 10) measured 690 feet of strata assigned to the Gros Ventre formation on the south slope of Baldy Mountain in Idaho. Wanless (personal communication, 1946) states that he measured 966 feet of the Gros Ventre formation in the Snake River Canyon, one half mile west of the Narrows. The lower shale member is 608 feet thick; the Death Canyon limestone is 201 feet thick; and the upper shale member is 157 feet thick. The formational name was applied by Blackwelder (1918, p. 417) to the type section on the western slope of Doubletop Peak in the Gros Ventre Range of Wyoming, where it has a thickness of 796 feet. The formation which is

middle Cambrian in age (Horberg, 1938, pp. 13-14), conformably overlies the Flathead quartzite.

Boysen formation.-- The Boysen formation is exposed in the series of overthrust sheets in the western part of the area mapped. These thrusts have been called the Palisades thrust complex. (See Palisades thrust complex). The Boysen formation is composed of blue to brownish-gray limestone with greenish silty partings and yellow to brown mottled areas (Gardner, 1944, p. 10). It is 212 feet thick in the Snake River Canyon, where it is a part of the Jordan Canyon thrust sheet (Wanless, personal communication, 1946).

The Gallatin formation originally described by Peale (1893, pp. 22-25) included both the Gros Ventre formation and the Boysen formation. Deiss (1938, pp. 1103-1105) found the use of the term "Gallatin formation" untenable because the formation was composed of rocks of two different ages. He proposed the use of the term "Boysen formation" for the rocks of upper Cambrian age. His type section is located two miles east of the Boysen dam in Wind River Canyon, Wyoming. The formation has three members: (1) the lower Maurice member which is composed of 182 feet of massive limestone, interformational conglomerate, and shale; (2) the Snowy Range member which is the middle unit, and consists of 308 feet of

shale, thin limestones and thick-bedded interformational conglomerates and (3) the upper Grove Creek member which is made up of 40 feet of maroon and buff dolomitic shales, mudstones, and edgewise conglomerates. These members were not found if present in the area of this report. The Boysen formation which is of upper Cambrian age (Deiss, 1938, pp. 1104-1105), lies unconformably on the Gros Ventre formation of middle Cambrian age.

Ordovician system

Bighorn dolomite.-- The Bighorn dolomite forms the Narrows in the Snake River Canyon. It is composed of light gray or cream to dark gray, fine to coarse grained, massive dolomite that weathers to a characteristic pitted surface. Some irregular pink to gray banding or mottling is also found. Gardner (1944, p. 10) has described the upper 150 feet as varying locally from dolomite to red and brown sandstone, siltstone, shale, or conglomerate. In the Snake River Range the lateral variation in thickness is very noticeable. Gardner measured 400 feet in the northern central part of the range and Wanless (personal communication, 1946) measured 732 feet in the Snake River Canyon at the Narrows.

Darton (1904, pp. 394-395) named the formation for its typical outcrop on the east side of the Bighorn

Mountains of Wyoming. He described it as 200 to 300 feet of light gray to buff limestone, which, when weathered, has a typical pitted surface. The Bighorn dolomite, which is Ordovician in age, rests unconformably upon the Boysen formation.

Devonian system (?)

Because of the extreme thinness of the Leigh formation it was mapped as the upper portion of the Bighorn dolomite.

Leigh formation.-- The Leigh formation is found in the Snake River Canyon at the Narrows where it is composed of a finely crystalline, brittle, white dolomite with a pitted weathered surface. The formation is 40 feet thick in Leigh Canyon, on the west slope of the Teton Range, where Blackwelder (1918, p. 419) first described it. Wanless (personal communication, 1946) found only 32 feet of the Leigh formation in the Snake River Canyon at the Narrows.

Blackwelder (1918, p. 419) named the formation for exposures in Leigh Canyon on the west slope of the Teton Range. It is of tentative Devonian age and lies conformably above the Bighorn dolomite. A Devonian age is tentatively assigned because of fish plates found in the Leigh formation on Glory Mountain in the Teton Range,

Wyoming. These appear to be of Devonian age (E. C. Case, personal communication, 1946).

Darby formation.-- The Darby formation lies immediately to the west of the Narrows in the Snake River Canyon and also on the north-south ridge, which contains Ferry Peak, where the Darby formation lies just beneath the capping Madison limestone. According to Gardner (1944, p. 10), the formation consists of 570 feet of strata, which is divisible into two members. The lower which is 360 feet thick, is made up of dark gray to sooty black limestone and dolomite, thin beds of light gray limestone, yellowish-brown siltstone, and a gray to brown sandstone. The upper member, 210 feet thick, is made up of yellow to purplish-red and brown calcareous and sandy shale, siltstone, and sandstone. A few layers of silty dolomitic limestone are also interbedded. Weathering causes the members to become yellow, brown, dark gray, olive, or reddish in color.

Wanless (personal communication, 1946) has measured 547 feet of the Darby formation which crops out immediately to the west of the Narrows. The strata are brownish-gray, massive dolomites with interbedded gray to black shales. The Darby formation which is of uncertain Devonian age (Blackwelder, 1918, p. 420), lies disconformably on the Leigh formation.

Mississippian system

In order to facilitate field mapping, the Madison and Brazer limestones were mapped as a single unit. This method was deemed practical, because the Brazer limestone is conformable on the Madison limestone, and the two form an easily recognizable unit in the field.

Madison limestone.-- In the area mapped the Madison limestone crops out widely in the form of prominent cliffs and talus slopes. It is nearly horizontal in attitude from Wolf Creek west to Sheep Gulch (which is not located on map - 1st canyon west of Cottonwood Creek), where, in places it is turned upward more than 90 degrees by the St. John thrust. It is also exposed along Ferry Peak ridge, where it is the capping formation and where its outcrop as a cliff contributes to the steepness of the eastern side of the ridge. The Madison limestone is a blue-gray, thin-bedded to massive, cliff-forming, coarse grained limestone which contains many calcite veins and chert. In some localities, the Madison limestone which is very fossiliferous, contains corals and brachiopods in abundance.

The Madison limestone in the Camp Davis area is 800 feet thick. Gardner (1944, p. 10) reports 1000 feet of this formation in the Snake River Range, Idaho. Peale

(1893, pp. 33-39) described the Madison limestone for its typical outcrop in the Madison Range, near the center of the Three Forks quadrangle in Montana. The Madison limestone which is of lower Mississippian age (Mansfield, 1927, p. 60), rests unconformably upon the Darby formation.

Brazer limestone.-- The Brazer limestone caps the Madison limestone in the Snake River Canyon from Wolf Creek west to a point just beyond Cottonwood Creek.

The Brazer limestone is light to dark gray in color and is thin-bedded to massive. Its texture is sublithographic to fine-grained and it contains a greater number of calcite veins and more chert than the underlying Madison limestone. Gardner (1944, p. 9) measured 265 feet of Brazer limestone in the Snake River Range of Idaho. In the Camp Davis area, the thickness is approximately 200 feet. The Brazer limestone which lies conformably on the Madison limestone, is upper Mississippian in age (Mansfield, 1927, p. 71).

Mississippian-Pennsylvanian system

The Amsden formation and the Tensleep sandstone were mapped as a single unit. They correspond to the older Wells formation, which was first described by Richards and Mansfield (1912, pp. 689-695). The type

section is in Wells Canyon, Bannock County, Idaho. Horberg (1938, pp. 16-17) followed this same pattern in his mapping in the Teton Pass area. The Tensleep sandstone lies conformably on the Amsden formation, which lies unconformably on the Brazer limestone.

Amsden formation.-- The Amsden formation crops out along the north side of the Grand Canyon of the Snake River from Wolf Creek westward to the Cottonwood Creek area where the Amsden formation has been dragged upward sharply by the St. John thrust fault. The Amsden formation also crops out on the south side of the South Branch of Indian Creek. The formation is composed of interbedded yellow, red, and brown shale with some limestones that are Brazer-like in appearance. Siltstones and sandstones, which are medium grained and resistant, are also found within the formation.

Darton (1904, pp. 398-401) reports a thickness of 150 to 350 feet of Amsden formation. Gardner (1944, p. 9) found 710 feet of the formation in the Snake River Range of Idaho. The original description of the formation was by Darton (1904, pp. 398-401). His type section is on the Amsden Branch of the Tongue River west of Dayton, Wyoming. The strata there are composed of an alternating series of shales, sandstones, and limestones.

The Amsden formation which is transitional in age from upper Mississippian to lower Pennsylvanian (Bachrach, 1945, pp. 64-68), rests unconformably upon the Brazer limestone.

Pennsylvanian system

Tensleep sandstone.-- The Tensleep sandstone is found along the northern side of the Grand Canyon of the Snake River, where it forms steep, high cliffs, which are very noticeable because of their rugged appearance. The formation also crops out along the South Branch of Indian Creek. The formation is essentially flat-lying over much of the area mapped; however, the formation is sharply upturned in the western portion of the area mapped because of the overthrusting of the St. John thrust sheet from the southwest. The major portion of the Tensleep sandstone consists of yellow to brown ortho-quartzite and sandstone with small amounts of gray cherty dolomite and limestone.

Darton's (1904, p. 397) section is 50 to 200 feet thick in the Bighorn Mountains, Wyoming. In the Camp Davis area, the thickness of the formation is 600 feet. Gardner's (1944, p. 9) section in the Snake River Range, Idaho is 1100 feet thick. The first description of the formation was by Darton (1904, p. 397). His type section

is in the lower canyon of Tensleep Creek in the Bighorn Mountains of Wyoming. The Tensleep sandstone, of Pennsylvanian age, lies conformably on the Amsden formation.

Permian system

Phosphoria formation.-- The Phosphoria formation caps the Tensleep sandstone throughout the area mapped and generally crops out about parallel to the 8,000 foot contour. The outcrops cut across Wolf Creek about four miles above the mouth, where the formation lies in the syncline between North Red Peak and Red Pass. The Phosphoria formation also caps the Tensleep sandstone cliffs in the South Branch of Indian Creek. It consists of two members, a lower phosphatic shale and an upper cherty limestone and dolomite. The lower phosphatic shale may be absent or may be one hundred feet thick. It is generally gray-black to brown in color and shows alternating beds of gray to brown calcareous and phosphatic mudstone, shale, and limestone. The upper unit is called the Rex Chert member. It consists of dark gray to black dolomite and gray, blue and brown limestone, which is silty and cherty, and contains a few fossiliferous zones and some sandstone and shale partings.

Gardner's Phosphoria formation consists of 147 feet of Rex Chert and 29 feet of phosphatic shale (1944, pp.

8-9). Krusekopf (personal communication, 1946) measured several sections of the Phosphoria formation during the summer of 1946. The lower shale at the head of Little Red Creek was 110 feet thick and the upper Rex Chert member was 147 feet thick. A second section was measured at the head of the north fork of Dry Fork of Wolf Creek. There the phosphatic shale was 90 feet thick and the Rex Chert member was 147 feet thick. Richardson and Mansfield (1912, pp. 684-689) described the formation for its outcrop in Phosphoria Gulch on the north side of Meade Peak in Idaho. The formation which is of Permian age (Richards and Mansfield, 1912, pp. 684-689), conformably overlies the Tensleep sandstone (Krusekopf, personal communication, 1946).

Triassic system

Dinwoody formation.-- The Dinwoody formation crops out on the ridge west of Red Creek, in the upper reaches of Dry Fork of Wolf Creek, and in upper Wolf Creek itself. The Dinwoody formation is made up predominantly of tan, limy shale and siltstone, with a few interbedded limestones.

On Martin's Creek, Snake River Canyon, Wyoming, the Dinwoody formation is 280 feet thick. In the Snake River Range, Idaho, Gardner (1944, p. 8) found 760 feet of the

formation. Blackwelder's (1918, pp. 425-426) original description of the formation shows a thickness of 200 feet of gray and olive siltstone and shale with thin brown limestone near the base. Blackwelder included all strata above the Phosphoria shale up to the bright red shale and siltstone of the Chugwater formation in his Dinwoody formation. Since the color change from gray to red beds, which Blackwelder used to delimit the top of the Dinwoody formation, is not a stratigraphic plane, Newell and Kummel (1942, p. 941) redefined the Dinwoody formation to include only those predominantly silty beds above the Phosphoria formation and below the top of the resistant siltstones. The thickness of the redefined Dinwoody at Dinwoody Canyon on the northeast slope of the Wind River Range near Du Bois, Wyoming, is 90 feet (Newell and Kummel, 1942, p. 941). In the area mapped, the Dinwoody formation is slightly over 600 feet thick. The Dinwoody formation, of lower Triassic age, lies unconformably on the Phosphoria formation.

Woodside formation.-- The Woodside formation crops out in Wolf Creek, in Dry Fork of Wolf Creek, and at the head of Red Creek. The formation is made up of calcareous red shaly siltstone, red shale, and thin beds of light colored sandstones.

The thickness of the Woodside formation varies greatly. In the area mapped, it was about 700 feet thick. Gardner (1944, p. 8) found 1100 feet of Woodside formation in the Snake River Range, Wyoming. Gray (1946, p. 15) measured a section on Fall Creek about a mile east of the Wilson road bridge in the Jackson quadrangle, Wyoming, and found the thickness to be 455 feet.

Boutwell's original Woodside formation (1907, p. 466) was defined in the Park City mining district, Utah, as a little over 1000 feet of maroon and red shaly siltstone. However, the lower part of Boutwell's Woodside formation corresponds stratigraphically to the Dinwoody formation to the north and east of the Park City mining district, Utah. (Newell and Kummel, 1942, p. 942). The Woodside formation is of lower Triassic age and lies conformably on the Dinwoody formation.

Thaynes formation.-- In the area mapped, the Thaynes formation caps many of the peaks between the Snake River and the South Branch of Indian Creek. It also forms Wolf Mountain and the upper basin of the West Branch of Wolf Creek. The Thaynes formation consists of interbedded, light colored, limestone, shale, and siltstone. Three major limy zones were recognized by Gray (1946, p. 22). The lowest may be equivalent to Mansfield's Ross Fork

limestone in Idaho, and the middle limestone to Mansfield's Portneuf limestone. Gray (1946, p. 22) suggests that the upper limestone may be a westward finger of the Alcova limestone of central Wyoming.

Gardner (1944, p. 8) found 970 feet of Thaynes formation present in the Snake River Range, Idaho. Gray (1946, p. 22) measured 935 feet of the Thaynes formation on the north bank of Fall Creek, about one mile east of the Wilson road bridge in the Jackson quadrangle Wyoming. The Thaynes formation was named by Boutwell (1907, pp. 434-458). The type section of the formation is in Thaynes Canyon of the Park City mining district of Utah. The Thaynes formation of lower Triassic age (Newell and Kummel, 1942, pp. 946-948) lies conformably over the Woodside formation.

Ankareh shale.-- The Ankareh shale crops out in the vicinity of North Red Peak and near Red Pass where the Wolf Creek trail joins the South Indian Creek trail. The Ankareh shale is composed of non-resistant red shale and siltstone, which are altered by weathering near the upper contact. Gardner (1944, p. 8) reports a bed of gray quartzite present in the Ankareh shale in the Snake River Range, Idaho.

The thickness of the formation varies considerably. Gray (1946, p. 12) measured a section on Fall Creek and found 161 feet of the formation present. Gardner (1944, p. 8) measured 550 feet of Ankareh between Palisade and Trail Creeks in the Snake River Range. In the area mapped, the thickness is about 400 feet.

Boutwell (1907, pp. 439-458) named the Ankareh shale for its typical occurrence on Ankareh Ridge within the Park City mining district of Utah. It consists of 1300 feet of red silicious detrital materials. Veatch (1907, p. 56) included in his Nugget sandstone approximately equivalent deposits in southwestern Wyoming. In 1912, Boutwell (pp. 58-59) redefined his Ankareh shale and called the upper part "Nugget sandstone." This is the designation that is commonly used. The Ankareh shale lies conformably on the Thaynes formation and is of middle to upper Triassic age (Mansfield, 1927, p. 374).

Jurassic system

Nugget sandstone.-- The Nugget sandstone crops out in the headwaters of Wolf Creek. It also caps the ridge which runs from Red Peak to Red Pass. White to tan, fine-grained, cliff forming sandstones comprise the Nugget sandstone, which may be locally quartzitic and may show aeolian cross-bedding. In the lower part, the sand-

stone is pinkish in color, because of some reworked reddish colored debris from the Ankareh shale which lies below. In the Snake River Range, Idaho, Gardner (1944, p. 8) found a 6 inch, pale greenish-gray, highly calcareous sandstone at the base of the formation.

The thickness of the Nugget sandstone seems to be fairly uniform over a considerable area. Gray (1946, pp. 12-16) reports a thickness of 325 feet on West Dell Creek, 5 miles above "Bellin's Ranch" in the Gros Ventre quadrangle Wyoming, and 350 feet of Nugget sandstone in Fall Creek, one mile east of Wilson Road bridge in the Jackson quadrangle Wyoming. Gardner (1944, p. 8) measured 340 feet of Nugget sandstone between Palisade and Trail Creeks in the northeast corner of the Irwin quadrangle, Idaho. The formation was named by Veatch (1907, p. 56). The type section is near the Nugget Station on the Oregon Short Line, in southwestern Wyoming. It is composed of 1900 feet of yellow, pink, and red sandstones. Mansfield (1920, p. 52) limited the use of the term Nugget sandstone to the upper member of the formation named by Veatch. The Nugget sandstone which is lower Jurassic in age (Mansfield, 1927, p. 17), lies unconformably on the Ankareh shale.

Gypsum Spring formation.-- The Gypsum Spring formation consists of gray limestone and a few red shales. Gray (1946, p. 40) measured 170 feet of the Gypsum Spring formation on Fall Creek in the Jackson quadrangle in Wyoming.

Love (et al., Prel. Chart #14, 1945) described the formation, which crops out in the Wind River Mountains, Wyoming, and is approximately 250 feet thick. There it is composed of sandy siltstone and white gypsum and anhydrite. The formation is of middle Jurassic age (Love, et al., 1945) and lies conformably upon the Nugget sandstone.

Twin Creek formation.-- The Twin Creek formation crops out in the center of the syncline between Red Peak and Red Pass. The formation is composed of gray fossiliferous limestone and shale. The limestones are oolitic, and the shales contain abundant gryphaea.

Dobrovolny (1938, p. 433) includes in the Twin Creek formation, 725 feet of strata above the top of the Nugget sandstone. Gardner's Twin Creek formation (1944, p. 7) is 970 feet thick. Gray's section (1946, p. 40) measured on Fall Creek, in the Jackson quadrangle, Wyoming, has a thickness of 476 feet.

Veatch (1907, p. 56) named the formation for its outcrop 100 miles to the south of the area mapped near Twin Creek, Wyoming, where it is from 3800 to 5500 feet thick and contains sandstone and shale, but no thick bedded limestone. The Twin Creek formation is middle to upper Jurassic in age (Imlay, 1945, pp. 1019-1022) and lies unconformably upon the Gypsum Spring formation.

Preuss sandstone.-- The Preuss sandstone is not found in the area mapped. However, it does cut across the Snake River Canyon between Station Creek and Wolf Creek, where, structurally, it is a part of the Little Gray's River anticline. The Preuss sandstone consists of white to red siltstone and fine-grained sandstone. A few thin red shale partings have been observed in certain localities.

The formation has a thickness of 124 feet on Fall Creek in the Jackson quadrangle, Wyoming (Gray, 1946, p. 39). Gardner's section contains only 55 feet of Preuss in the Snake River Range, Idaho (1944, p. 7). Mansfield and Roundy (1916, p. 81) however, found 1300 feet of Preuss sandstone 12 miles northeast of Montpelier, Idaho.

The Preuss sandstone is the lower member of Veatch's older Beckwith formation (1907, p. 56) which contained from 3800 to 5500 feet of sandstones and shales. The type locality of the Preuss sandstone is near Preuss Creek, 12 miles northeast of Montpelier, Idaho. The Preuss sandstone is upper Jurassic in age (Mansfield, 1927, p. 99) and lies unconformably on the Twin Creek formation.

Stump sandstone.-- The Stump sandstone is nowhere exposed in the area mapped, but it does crop out in the canyon of the Snake River between Wolf Creek and Station Creek, where it is a part of the Little Gray's River anticline.

The Stump sandstone is characteristically green because of the presence of glauconite, and it is generally fine grained and calcareous. Some limestone may be present, and it is generally sandy or shaly; it also contains considerable glauconite.

Mansfield and Roundy (1916, p. 81) include 200-600 feet of strata in their description of the formation at Stump Peak in Idaho. Gray (1946, p. 38) found only 96 feet of the formation on Fall Creek in the Jackson quadrangle, Wyoming. Gardner (1944, p. 7) measured 140 feet of Stump sandstone in the Snake River Range, Idaho. The

Stump sandstone was named by Mansfield and Roundy (1916, p. 81) for exposures at the head of Stump Creek on Stump Peak, T 6S, R 45E, Boise meridian (unsurveyed). It is upper Jurassic in age (Mansfield, 1927, p. 101) and conformably overlies the Preuss sandstone.

Cretaceous system

Gannett formation.-- The Gannett formation is not exposed in the area mapped; however, it does crop out immediately to the eastward in the canyon of the Snake River between Wolf Creek and Station Creek. The Gannett formation usually consists of at least three members. The lower is made up of red shale and light gray limestone; the middle of a gray massive lithographic limestone; the upper of gray shale and limestone with a mudstone at the upper contact.

Gray (1946, p. 36) has measured a Gannett section on Fall River, in the Jackson quadrangle, Wyoming and found the thickness to be 686 feet. Gardner (1944, p. 7) found 940 feet of Gannett formation (which he terms the Gannett group) on the ridge between Palisade and Trail Creeks, Irwin quadrangle, Idaho.

The Gannett formation was first included within Veatch's Beckwith formation (1907, p. 56). Mansfield

and Roundy (1916, pp. 75-84) divided the Beckwith formation into the Preuss sandstone, the Stump sandstone, and the Gannett group which contained the Ephraim conglomerate, the Peterson limestone, the Belcher conglomerate, the Draney limestone and the Tygee sandstone. Gray (1946, pp. 36-38) calls the Gannett a group but does not subdivide it into its formational components. This method of not applying the formational names where the strata are too thin to be easily recognized was first used by Horberg (1938, p. 21). The Gannett formation which is of lower Cretaceous age (Mansfield, 1927, pp. 101-105), rests unconformably upon the Jurassic Stump sandstone.

Bear River formation.-- The Bear River formation does not outcrop in the area mapped; however it is exposed in the Snake River Canyon between Wolf Creek and Station Creek. The Bear River formation is composed of interbedded tan sandstones and black shales in the lower part and black shale, thin sandstones, and freshwater limestones in the upper part.

Dobrovolny (1938, p. 46) found the Bear River formation to be 970 feet thick on Willow Creek, near Camp Davis, Wyoming. Gardner (1944, p. 8) has measured 880 feet of Bear River formation in the Palisade Creek area,

Snake River Range, Idaho. The Bear River formation was named by Hayden in 1869 (pp. 91-92) for strata outcropping near Bear River City, Wyoming. The formation is from 500 to 5000 feet thick. On the basis of a faunal collection made by La Rocque (personal communication, 1946), the formation has been assigned to a lower Cretaceous age. The Bear River formation lies unconformably on the Gannett formation.

Aspen formation.-- The Aspen formation is not found within the area mapped, but it crops out to the east of the Absaroka thrust, where it is exposed over an area of several square miles. The Aspen formation is composed of a lower member containing 365 feet of gray-green sandstone interbedded with black shale, and an upper unit consisting of 595 feet of rhyolitic tuffs interbedded with tuffaceous siltstones. Seven separate porcelenite beds are found in Willow Creek, near Camp Davis. The porcelenites resemble porcelain megascopically, but microscopically they consist mainly of fine unweathered fragments of volcanic glass (Dobrovolny, 1938, p. 438). Rubey (1928, p. 156) reports vitric rhyolitic tuff from the Aspen formation in southwestern Wyoming and he compares it with the tuff found in the Mowry shale of northeastern Wyoming. Dobrovolny (1938,

p. 438) concludes from this evidence that, since the Aspen formation near Camp Davis has considerably more tuff than the Mowry shale, it may have been deposited closer to the volcanic source. Eardley (1944, p. 824) reports 250 feet of Aspen formation in the north-central Wasatch Mountains with some tuff beds present there also. Gardner (1944, p. 6) found the Aspen strata in the Snake River Range, Idaho to total 2,015 feet in thickness and to contain many porcelenite beds. The formation which is of upper Cretaceous age (Veatch, 1907, pp. 64-65), lies conformably on the Bear River formation.

Frontier formation.-- The Frontier formation is not exposed in the area mapped. Ross and St. John (personal communication, 1947) however, have mapped extensive areas of the Frontier formation to the west of Grayback Ridge in the southeastern corner of the Jackson quadrangle, Wyoming. The Frontier formation is composed of gray to buff arkosic sandstone, siltstone, and shale. The lower portion may contain some reworked tuff from the upper Aspen formation. Several coal beds are found about 1100 feet above the base of the formation. The thickness of the formation is extremely variable, because the top of the formation has been removed by erosion throughout most of the area. Ross and St. John

(personal communication, 1947) measured 5,290 feet of the formation on Deadman Mountain, in the Wyoming Range, Wyoming. It was measured from the base of the formation upward until the Darby thrust plane was encountered.

Knight (1902, p. 721) first described the formation near Frontier, Wyoming where it consists of 2000 feet of thick evenly bedded, light brown sandstones, which are coal bearing in many areas. The Frontier formation which is in the Colorado epoch of the upper Cretaceous period (Veatch, 1907, p. 69), conformably overlies the Aspen formation.

Eocene series

Hoback formation.-- The Hoback formation crops out in the Hoback River Basin, which lies 20 miles to the east of Red Creek area. It is composed of gray to brown sandstone, shale with several conglomerate lenses, and impure fresh water limestone. Low grade coal seams occur in the lower part of the formation. The thickness of the formation was estimated by Eardley et al, (1944) to be approximately 15,000 feet. The formation which is lower Eocene in age, lies unconformably upon older formations.

Pass Peak conglomerate.-- The Pass Peak conglomerate crops out in the Hoback River Basin, which lies 20 miles to the east of the Red Creek area. It is composed of 3,000 feet of red to gray coarse conglomerate, whose boulders are characterized by the presence of percussion marks. The conglomerate grades upward into sandstone and shale. The Pass Peak conglomerate which is middle Eocene in age (Eardley, et al, 1944), lies conformably on the Hoback formation.

Miocene formation

Camp Davis conglomerate.-- The Camp Davis conglomerate does not crop out in the Red Creek area; however, it occurs in the Grand Valley of the Snake River, Idaho, which is three miles to the west of the Red Creek area, Wyoming. A small remnant of the Camp Davis formation is also found to the east of the area mapped at the junction of Bailey Creek and the Snake River. Predominant conglomerates comprise the formation in the type area, which is north of the Hoback River, near Camp Davis. The lower conglomerate is gray in color and is 200 feet thick, a 50 foot impure fresh water limestone comprises the middle member, and the upper conglomerate is red or tan and is at least 2000 feet thick.

The formation was described by Eardley, et al, (1944). Prior to that date, it was considered to be the Almy conglomerate of Paleocene age (Veatch, 1907, pp. 76-87) (Schultz, 1914, p. 30). In 1924, the formation was referred to as the Salt River formation by Kirkham (pp. 29-30). Eardley (1942, p. 1800) described the manner in which the Camp Davis formation was deposited. The first phase was initial folding and thrusting in Laramide time, which was then followed by high angle normal faulting which formed a trough in which the sediments accumulated. As the fault escarpment was eroded back, deposition partially filled the trough and covered the fault scarp. The presence of a fossil horse's tooth near the base of the fresh water limestone is the basis of limiting the formation to a range of upper Miocene to lower Pliocene in age (Eardley, 1942, p. 1800).

GENERAL IGNEOUS GEOLOGY

Only minor quantities of igneous rock occur within the Red Creek area of the Snake River Range in Wyoming. An andesitic sill crops out on the West Branch of Wolf Creek and a stock of light colored diorite crops out just east of North Red Peak. Several small dikes are associated with the Red Peak stock.

Size and shape of intrusives

The sill on the West Branch of Wolf Creek is from 10 to 15 feet thick and intrudes the Thaynes formation. It crops out along the stream course. In many places it forms an impermeable barrier to impede the downward migration of ground water in the host rock. This is shown by the presence of large springs along the sill outcrops. The lateral extent of the sill and its relationship to the Red Peak stock are not known.

The Red Peak stock, which crops out just to the east of North Red Peak, is approximately one half mile long and one quarter mile wide. Several smaller igneous bodies are apparently dikes.

Petrology

From a megascopic viewpoint the Wolf Creek sill is a fine-grained andesite composed of plagioclase feldspar, hornblende, and augite. In thin section, the rock shows a micro-porphyritic texture with phenocrysts of plagioclase, hornblende, and augite set in a fine grained to aphanitic matrix containing plagioclase, magnetite, apatite, and glass which is considerably altered. Diopside may also be present in small amounts.

The Red Peak stock contains rocks classed in the field as granitic, but low in quartz. The mafic mineral is almost entirely hornblende. Three thin sections of the rock reveal only minor textural variations. The types are micro-porphyritic diorite and porphyritic diorite. The textures indicate that the intrusive is probably hypabyssal in origin.

Three specimens were taken from intrusives associated with the Red Peak stock. The first, from a dike northeast of North Red Peak, is identified as a highly altered andesite. In thin section, the rock can be classed as a porphyritic diorite with calcic andesine feldspar and hornblende. The latter has been almost completely altered to chlorite. Glass occurs in the matrix in small amounts. The two specimens from just

south of North Red Peak were identified as highly altered granites in hand specimen. However, in thin section one is found to be a porphyritic diorite; whereas, the other is a granite containing some albite feldspar. The detailed descriptions are given in Appendix A.

Age Relations

The youngest formation cut by the intrusive is the Jurassic Thaynes formation. Therefore, the intrusion is at least post-Thaynes in age. Because the exact age of intrusion cannot be determined from the field relations, it is suggested that due to the manner in which the intrusives cut the nearly horizontal thrust sheets, they may be post-thrusting and therefore may be post-upper Paleocene in age.

STRUCTURAL GEOLOGY

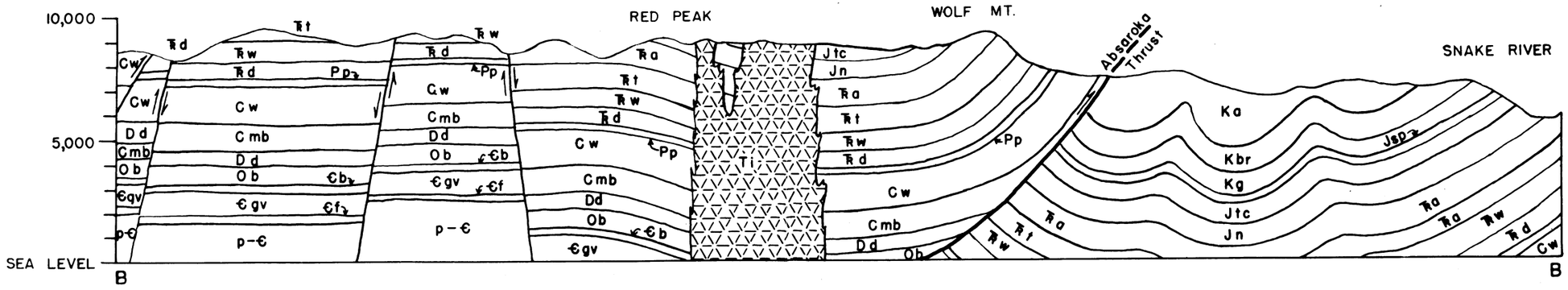
General features

The geology of central western Wyoming is characterized by two types of structures, the Laramide and the Mid-Tertiary. The Laramide structures are composed of large thrust sheets and broad gentle folds. The Mid-Tertiary structures are high angle normal faults.

Laramide structures

Palisade thrust complex.-- The Palisade thrust complex is composed of three separate thrust sheets, the Blowout Canyon, the Needle Peak, and the Ferry Peak. The thrust complex is well developed in the Calamity Point area of Idaho, where the upper two thrust sheets, the Blowout Canyon and the Needle Peak, were named for prominent geographic features (Enyert, 1947, plate 2). The lower two thrust sheets, the Needle Peak and the Ferry Peak, are recognizable in the Red Creek area, but the Blowout Canyon thrust sheet is absent.

Needle Peak thrust sheet.-- The Needle Peak thrust sheet was named for exposures of the thrust trace on Needle Peak, in the Calamity Point area of Idaho, where the Boysen and Bighorn formations rest on the Ferry Peak thrust sheet (Enyert, 1947, plate 3). In the Red Creek



Cross-sections of Red Creek Area, Snake River Mountains, Wyoming, to accompany Plate 2, geologic map; — p-€, pre-Cambrian; €f, Flathead quartzite; €gv, Gros Ventre formation; €b, Boysen formation; Ob, Bighorn dolomite; Dd, Darby formation; Cmb, Madison-Brazer limestone; Cw, Wells formation; Pp, Phosphoria formation; Tr d, Dinwoody formation; Tr w Woodside formation; Tr t, Thaynes formation; Tr a, Ankareh formation; Jn, Nugget sandstone; Jtc, Twin Creek formation; Jsp, Stump-Preuss sandstone; Kg, Gannett formation; Kbr, Bear River formation; Ka, Aspen formation; Tcd, Camp Davis conglomerate; Ti, Tertiary intrusives.

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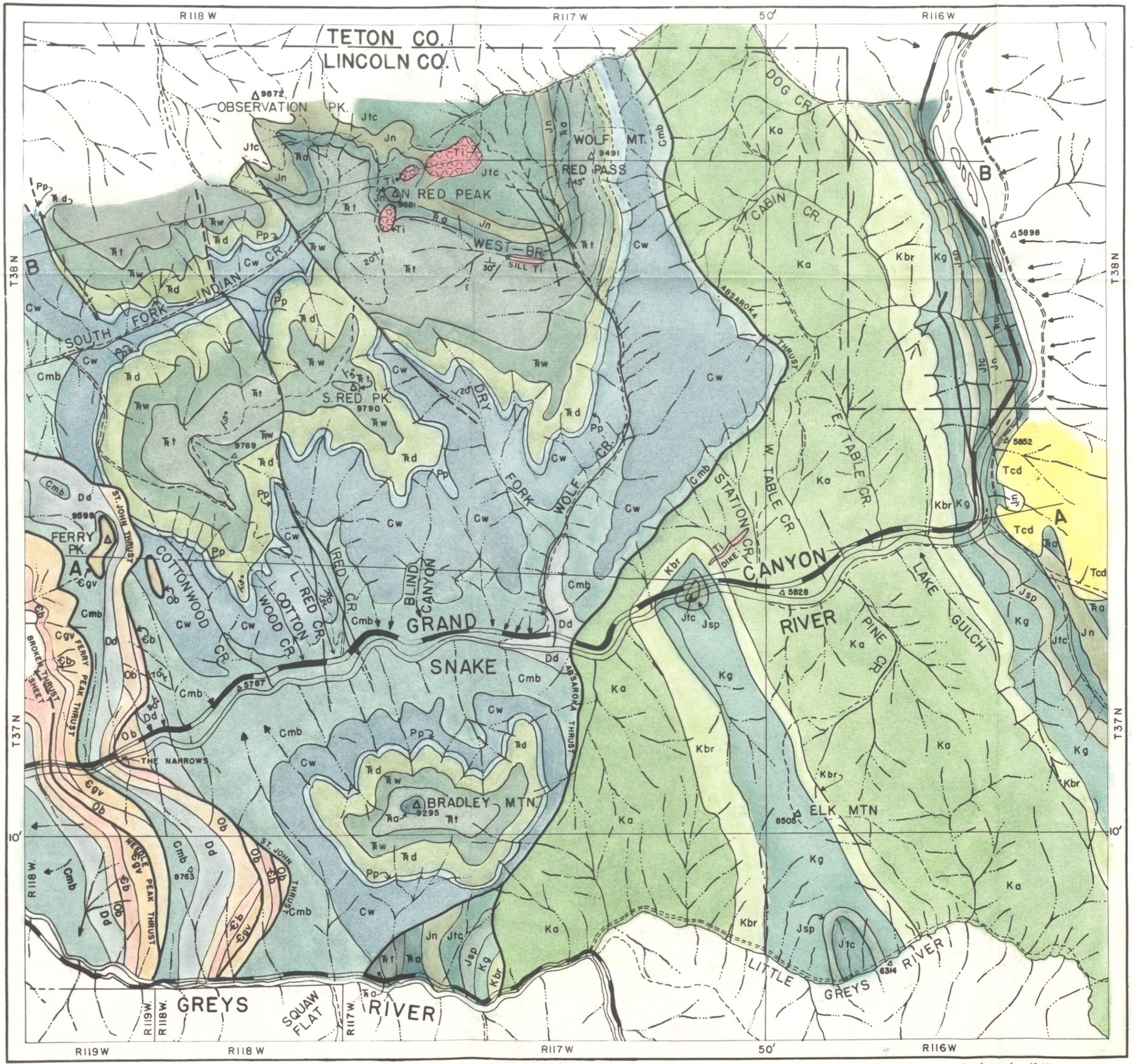
area, the Needle Peak thrust sheet consists of the Boysen, Bighorn, Darby, and Madison formations. The thrust sheet dips 40 degrees to the southwest and rests on the Ferry Peak thrust sheet. The trace of the fault extends from the northern limits of the Calamity Point area of Idaho, into the Red Creek area of Wyoming, and it has been traced as far south as the Greys River.

Ferry Peak thrust sheet.-- The Ferry Peak thrust sheet was named for the exposure of the thrust trace immediately to the west of Ferry Peak. The fault can be traced northwestward from Ferry Peak where it is covered by the Needle Peak thrust sheet. The fault trace reappears north of Blowout Canyon and has been traced as far north as Palisades Creek (Enyert, 1947, plate 2). To the south of Ferry Peak, the fault crosses the Snake River, just west of the Narrows, and it has been traced southward from the Narrows to a point just north of Greys River, where the Needle Peak thrust sheet covers the fault trace (Bastanchury, 1947, plate 2). The dip of the thrust sheet in the Red Creek area is 50 degrees to the southwest. It rests on the St. John thrust sheet.

St. John thrust sheet.-- The St. John thrust sheet (Schultz, 1914, pp. 35-36) is composed of part of the Boysen formation, together with the Bighorn, Darby, and



LEGEND

Tcd	Camp Davis conglomerate	Tertiary
Ka	Aspen formation	Cretaceous
Kbr	Bear River formation	
Kg	Gannett formation	
Jsp	Stump- Preuss sandstone	Jurassic
Jtc	Twin Creek formation	
Jn	Nugget sandstone	
Ra	Ankareh formation	Triassic
Rt	Thaynes formation	
Rw	Woodside formation	
Rd	Dinwoody formation	
Pp	Phosphoria formation	Permian
Cw	Wells formation	Carboniferous
Cmb	Madison–Brazer limestone	
Dd	Darby formation	Devonian
Ob	Bighorn dolomite	Ordovician
€b	Boysen formation	Cambrian
€gv	Gros Ventre formation	
€f	Flathead quartzite	
p-€	schist and gneiss	Tertiary PreCambrian
Ti	Tertiary intrusives	

SCALE

1 0 1 2 MILES

Base from U.S. Geological Survey topographical map Jackson quadrangle, Wyoming.

Geologic Map
Red Creek area, Wyoming

Geology by K. Keenmon, R. Bastanchury, L. Otton, W. Osterling.

Madison formations. The trace of the thrust fault passes just to the east of Ferry Peak and has been traced southward to the Snake River, where the Narrows is formed by the Bighorn dolomite. To the south of the Narrows, the thrust trace trends eastward as it rises over the mountainous area. The last recognized southerly exposure of the thrust plane is just west of Squaw Flat on Greys River (Bastanchury, 1947, plate 2). From Ferry Peak northward, the fault can be traced to Indian Creek, and then northeastward to North Indian Creek Pass. From this point, the trace of the fault trends westward into Elk Creek and then continues northward across Palisades Peak to Palisades Creek (Enyert, 1947, plate 2). The dip of the thrust plane is approximately 50 degrees to the southwest. The St. John thrust sheet rests on the Absaroka thrust sheet. (See geologic cross section A-A, plate 3). According to Kirkham (1924, p. 33), the St. John thrust is probably a west branch of the Absaroka thrust. The value of this conclusion will only be known after detailed mapping has been completed south of Greys River.

Absaroka thrust sheet.-- The Absaroka thrust was first mapped by Veatch (1907, p. 109) in Uinta County, Wyoming as the "big thrust." In 1914, Schultz (p. 87)

applied the term Absaroka thrust to Veatch's "big thrust." Schultz traced the fault a distance of 90 miles from Oyster Ridge, which is 20 miles north of Kemmerer, Wyoming, to the junction of Wolf Creek with the Snake River. Osterling (personal communication, 1947) has extended the trace of this fault to the vicinity of Wolf Mountain which is 6 miles to the north of the Snake River (See geological map, plate 2). In the Red Creek area, the Absaroka thrust sheet is a massive block 5 to 8 miles in width composed of essentially horizontal Paleozoic and Mesozoic formations, which rest on the Darby thrust sheet. Near the fault trace the beds are upturned. (See geologic cross section, plate 3).

Mid-Tertiary structures (?)

Most Mid-Tertiary structures in central western Wyoming are characterized by high-angle, normal faults. In the Grand Valley of the Snake River, Idaho, the Snake River and Grand Valley faults are Mid-Tertiary, high-angle, normal faults which cut the Laramide thrust sheets (Enyert, 1947, p. 23). The general trend of these faults is northwest-southeast. The high angle normal faults in Red Creek and in Dry Fork of Wolf Creek are oriented in a northwest-southeast direction. Since these faults cut

the Thaynes formation, they must be at least post-Thaynes in age. However, the fact that these faults parallel the Grand Valley faults and are high-angle is evidence that they are Mid-Tertiary in age.

Spatial relations

Western Wyoming is characterized by two distinct types of structural provinces, the shelf province, and the geosynclinal province (Horberg, 1938, p. 28). The Wind River, Gros Ventre, and Teton Ranges are characteristic examples of the shelf zone of sedimentation, and their structures are typically large asymmetrical folds (See index map, plate 1). The Snake River, Salt River, Caribou, and Hoback Ranges are typical examples of the geosynclinal province, whose structure is characterized by thrust sheets of great thickness composed of Paleozoic and Mesozoic sediments.

The Darby, Absaroka, and Bannock thrusts are huge thrusts which have a great displacement (See tectonic map, plate 4). Both the Darby and Absaroka thrusts are found in the Snake River Range, but the Bannock thrust lies further to the southwest in Idaho.

A system of high angle faults has been mapped in eastern Idaho and western Wyoming near Camp Davis. These

high angle faults cross the earlier Laramide structures. Their location is determined by the presence of long prominent fault scarps and inter-montaine valleys filled or partly filled with conglomerate and volcanics. These faults have caused downward tilting of the fault blocks, to form what in some places resembles a graben. The Snake River Valley, Idaho is such a downward tilted block and is bounded by the Snake River and Grand Valley faults (Enyert, 1947, p. 23). The throw of the faults is from 1000 to 5000 feet. The Jackson Hole region of Western Wyoming is another downward tilted fault block and is bounded on the west by the Teton fault (See index map, plate 1). Evidence of this fault is readily visible in the long prominent fault scarp which trends north-south along the east face of the Teton Range. The Hoback fault runs from Jackson Hole southeastward along the Hoback Range and has been mapped as far south as the vicinity of Hoback Peak (Ross and St. John, 1947, plate 1).

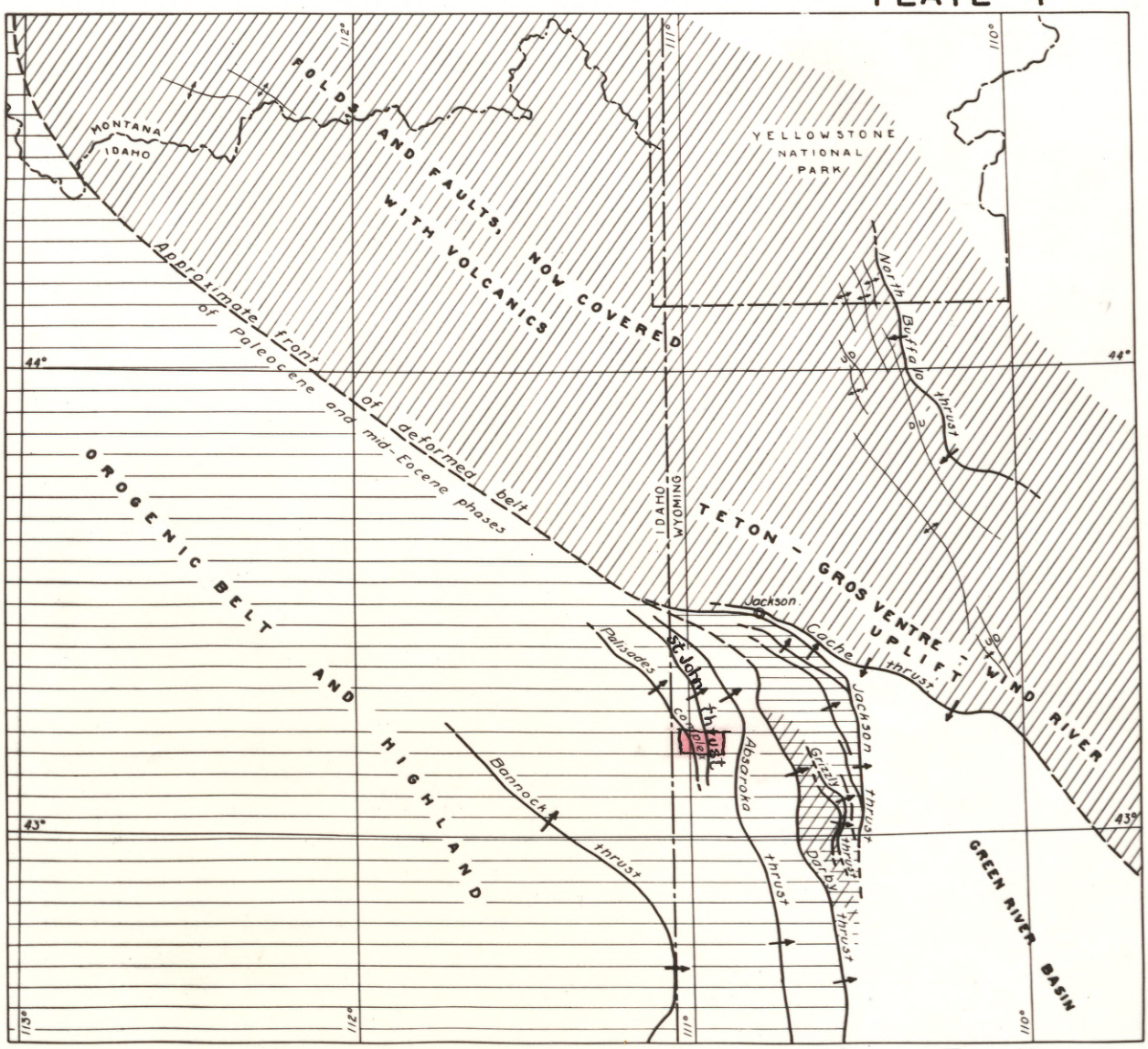
Since the high angle faults are discordant with the Laramide structure, the intermontaine valleys resemble a rift zone. The Basin and Range province of northwestern Arizona and western Utah may extend northward into southeastern Idaho and western Wyoming and include the area of this report (Eardley, personal communication, 1947).

Age relations

During the Laramide orogeny, the Darby and Absaroka thrust sheets overrode eastward. This eastward overthrusting has been pointed out by Schultz, Mansfield, and Kirkham, who have made extensive studies in central western Wyoming and eastern Idaho. More recent work by Ross and St. John (1947, p. 21) shows that the Darby thrust in the Wyoming Range has overridden the entire Paleozoic and Mesozoic sections, including more than 5000 feet of the upper Cretaceous Frontier formation (See plates 1 and 4). Evidence noted by Eardley (personal communication, 1946) in north central Utah and southwestern Wyoming, shows that the Darby and Absaroka thrusts are covered by the Almy conglomerate, which is of upper Paleocene age. Therefore, the age of thrusting is post-Colorado (Frontier formation) to pre-upper Paleocene (Almy conglomerate). Thus, the Darby and Absaroka thrust sheets and their branching thrusts, the St. John and the Palisade thrust complex, were formed in the first stage of the Laramide orogeny, which is Paleocene in age.

In the Hoback Range, some 25 miles to the east of these thrusts, the Hoback formation of lower Eocene age crops out. It is believed that the source of the sediments of the Hoback formation was the great Darby and

PLATE 4



after Eardley

TECTONIC MAP

Western Wyoming and Eastern Idaho

Absaroka thrust sheets (Eardley, personal communication, 1947).

The Jackson, Cabin, and Clause thrust sheets which lie to the east of the Absaroka and Darby thrusts, moved eastward and cut the Hoback formation, which is lower Eocene in age (See tectonic map, plate 4). These thrusts are overlapped by the Pass Peak conglomerate in the Hoback Mountains. Since the Pass Peak conglomerate is middle Eocene in age, the Jackson, Cabin, and Clause thrusts must be post-lower Eocene (Hoback formation) and pre-middle Eocene (Pass Peak conglomerate) in age; also these thrusts represent a second stage of the Laramide orogeny.

A third stage of deformation of the Laramide orogeny is indicated by the Grizzly thrust, which moved to the northeast (See tectonic map, plate 4). The Cache Creek thrust, which opposed the Grizzly thrust, was formed at the same time. Since both of these thrusts cut the Pass Peak conglomerate, the faults post-date the Pass Peak conglomerate which is of middle Eocene age. The Cache Creek thrust is covered by the Camp Davis conglomerate of upper Miocene to Lower Pliocene age. Therefore, the Grizzly and Cache Creek thrusts are post-middle Eocene (Pass Peak conglomerate) to upper Miocene (Camp Davis conglomerate) in age and represent a third stage of the Laramide orogeny.

SUMMARY OF EVENTS

During Paleozoic and Mesozoic time, marine and non-marine geosynclinal deposits accumulated in the Western Wyoming area. At the close of Upper Cretaceous time, orogenic forces became active, and the first stage of the deformation is represented by imbricate thrust sheets which are of Paleocene age. The imbricate thrust sheets in the Red Creek area, which moved to the northeast, are the Needle Peak, Ferry Peak, and St. John sheets. These thrust sheets are branches of the Absaroka thrust, which is also Paleocene in age. The intrusion of the Red Peak pluton may be a late phase of this deformation.

In post-Paleocene time, the Darby and Absaroka thrust sheets were eroded, the sediments from these sheets being deposited to the east in the Hoback Basin as the Hoback formation of lower Eocene age. The Jackson, Cabin, and Clause thrust faults cut the Hoback formation, but they are covered by the Pass Peak conglomerate of middle Eocene age. Thus, the second stage of the Laramide orogeny is post-lower Eocene to pre-middle Eocene in age.

The Pass Peak conglomerate of middle Eocene age was cut by the eastward moving Grizzly thrust sheet and the westward moving Cache Creek thrust sheet. The trace of

the Cache Creek fault is covered by the Camp Davis conglomerate of upper Miocene to lower Pliocene age. Therefore, the age of the third stage of the Laramide orogeny is post-Middle Eocene to pre-upper Miocene or lower Pliocene.

APPENDIX A - PETROGRAPHY

West Wolf Creek sill

This sill is composed of a fine-grained micro-porphyritic andesite. Abundant phenocrysts of alkalic labradorite (Ab 46) have been considerably altered to sericite. The mafic minerals, also in phenocrysts, are hornblende, which shows a dark green pleochroism; augite; and either aegirine or aegirine-augite. A few scattered augite crystals show rims of hornblende. The groundmass is fine-grained to aphanitic and contains plagioclase feldspar, magnetite, apatite, and some altered glass. Secondary calcite and chlorite also are present.

Red Peak stock

Three thin sections made from specimens obtained from talus blocks on the north side of the Red Peak stock were studied. These rocks are porphyritic diorites. One has a micro-porphyritic texture containing phenocrysts of andesine in two different sizes. Some of the larger phenocrysts have been broken. They are well zoned and the change in composition is illustrated by the alteration of the inner zone to kaolinite. Small amounts of both orthoclase and microcline also are present. Approximately equal amounts of hornblende and augite and smaller amounts

of magnetite are the mafic constituents. The hornblende exhibits both poikilitic structures, with inclusions of magnetite and apatite, and well developed zoning. The interior parts of the crystal are lighter green than the rims. The augite is light yellow green and contains zonally arranged inclusions. Some ilmenite, which is bordered by reaction rims of secondary sphene, is also present. Zircon is a minor accessory. Dusty magnetite, kaolinite, limonite, and chlorite are alteration products.

Another thin section of the Red Peak stock contains no microcline, but a small amount of orthoclase may be present. The plagioclase is andesine and commonly is well zoned. The outer shells are altered to kaolinite, but the cores are unaffected. This may possibly indicate an example of reverse zoning, for the more calcic zones are generally more susceptible to kaolinization (Heinrich, personal communication, 1947). The mafic minerals are hornblende, which has been largely altered to chlorite, and biotite mica in small amounts, also chiefly altered to chlorite and magnetite. A little muscovite mica and quartz are also present. Apatite, sphene, zircon, and fluorite are accessory minerals. Limonite and hematite are alteration products.

The third section is of a porphyritic diorite with phenocrysts of orthoclase, plagioclase, and hornblende. The plagioclase is zoned andesine and is altered to white mica and kaolinite. Small amounts of augite or aegirine-augite are also present. Sphene, apatite, and ilmenite with leucoxene occur as accessories. A small crystal of garnet, possibly andradite, was also identified. Sericite, dusty magnetite, limonite, and leucoxene are alteration products.

Associated dikes

A specimen from the dike just northeast of North Red Peak has been identified as a porphyritic gabbro with a fine-grained matrix. The plagioclase feldspar is labradorite much of which has been completely altered to kaolinite. Small amounts of highly kaolinized orthoclase feldspar may also be present. The hornblende has rounded outlines and appears to be partially resorbed. It is rimmed with magnetite. Apatite and magnetite are accessories. The groundmass may have been a glass, but is now highly altered to calcite, magnetite, chlorite, white mica, limonite, and hematite.

One of two specimens taken from south of North Red Peak is a porphyritic diorite. The plagioclase feldspar is andesine. Most of it is zoned and some is altered to

kaolinite. The main mafic constituents are hornblende, biotite, and augite with hornblende rims. Either aegirine-augite or aegirine is present in minor amounts. Quartz, apatite, and zircon are accessories. Magnetite has been altered to limonite and hematite.

Another specimen is a granite or quartz-monzonite, which has been highly altered and shows some vein-like structures that suggest hydrothermal alteration. Both orthoclase and plagioclase are present. The plagioclase is albite and it is largely altered to sericite. A small amount of biotite occurs and the mineral appears to be partially resorbed. Quartz is abundant. Magnetite and apatite are accessories. Chlorite and hematite are alteration products.

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