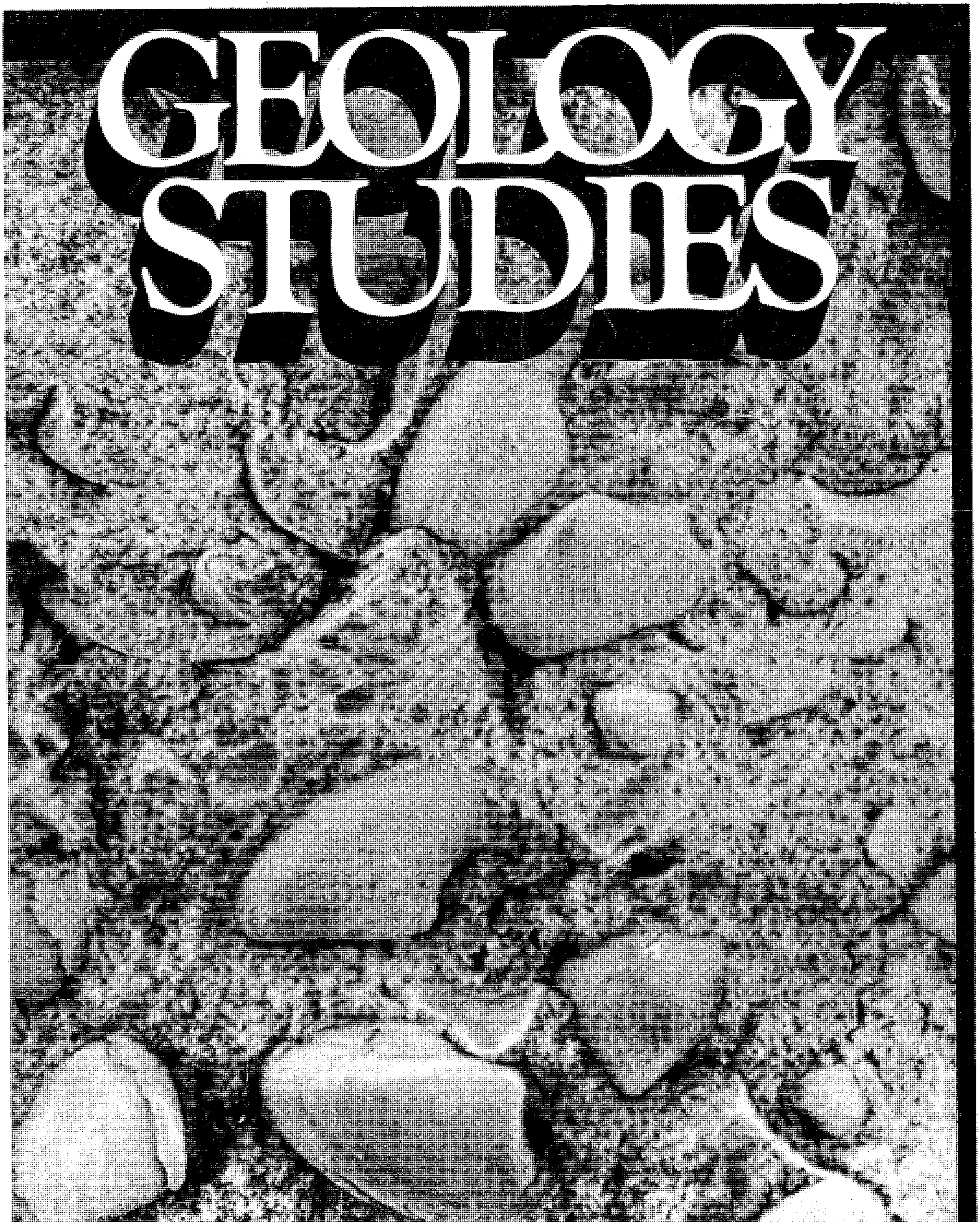
BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES



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Cover: Slab of bivalves showing Myalina-Pleuroma *suite, from Torrey section, Sinbad Limestone Member, Moenkopi Formation in the Teasdale Dome Area, Wayne County, Utah. Photo courtesy James Scott Dean.*

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CONTENTS

Geology of the Auburn 7½′ Quadrangle, Caribou County, Idaho, and Lincoln County, Wyoming*

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ABSTRACT.—The Auburn Quadrangle straddles the Idaho-Wyoming border in the central part of the Overthrust Belt. Bedrock exposed is about 5,000 m thick, comprising in ascending order, Rex Chert Member of the Phosphoria Formation, Dinwoody Formation, Woodside Formation, Thaynes Formation, Higham Grit, Ankareh Formation, Nugget Sandstone, Twin Creek Limestone, Preuss Sandstone, Stump Sandstone, Gannett Group, Tygee Member of the Bear River Formation, and the Wayan Formation. The Tertiary Salt Lake Formation lies with angular unconformity over older strata and covers much of the topographically lower parts of the quadrangle. The older strata crop out in a series of north-northwest-trending folds, named, from west to east, the Boulder Creek Anticline, Spring Creek Syncline, Miller Creek Syncline, and the Hemmert Anticline.

The Meade Thrust separates the Meade and Absaroka plates. Thrust imbrications of the hanging and footwall were mapped, as well as numerous small transverse faults. Folding and faulting were contemporaneous and occurred intermittently from the end of Early Cretaceous until Late Cretaceous. These structures are cut by Miocene to Recent basin-and-range faults.

Two wells were drilled in the 1920s in the Auburn Quadrangle; both had shows of oil. Additional petroleum exploration seems warranted.

INTRODUCTION

Fifty-three years ago Mansfield (1927) mapped the Freedom 15-minute Quadrangle of which the Auburn Quadrangle makes up the southeastern quarter. A new 1:24,000 base map and high quality aerial photography now make it feasible to remap this quadrangle in an effort to better understand the structure and stratigraphy of this important segment of the Wyoming-Idaho Overthrust. The Auburn 7½-minute Quadrangle is situated in the Overthrust Belt, approximately 57 km northeast of Montpelier, Idaho, and 9 km northwest of Afton, Wyoming, along the Idaho-Wyoming border (fig. 1). The quadrangle lies, in part, in Caribou County, southeastern Idaho, and, in part, in Lincoln County, southwestern Wyoming. About half of the area is privately owned with the remainder in the Caribou National Forest. Most of the area is accessible via a state-maintained dirt road, Forest Service dirt roads, and private dirt roads.

Previous Work

The area was mapped at a scale of 1:62,500 by Mansfield (1927), who also summarized prior geologic work. Several 7½-minute quadrangles near and adjacent to the Auburn Quadrangle have been recently mapped: Cressman and others (1964), Snowdrift Mountain Quadrangle; Montgomery and Cheney (1967), Stewart Flat Quadrangle; Hatch (1980), Elk Valley Quadrangle; and Conner (1980), Sage Valley Quadrangle (fig. 1).

Mansfield (1927) summarized the structural history of southeastern Idaho and southwestern Wyoming. Armstrong and Cressman (1963) described the prominent folded Bannock Overthrust which Cressman (1964) renamed the Meade Overthrust. Two shallow wells were drilled in the quadrangle in the late 1920s but were dry (Hodgden and McDonald 1977).

Method of Study

Fieldwork was carried out during the summer of 1980. Data from field mapping were recorded on 1:15,000 color aerial photographs and later transferred to a U.S. Geological Survey preliminary map of the Auburn 7½-minute Quadrangle. Stratigraphic sections were measured and described by conventional methods.

ACKNOWLEDGMENTS

The writer expresses his thanks to Dr. Lehi Hintze who served as committee chairman and made numerous helpful suggestions relating to mapping problems and manuscript writing; to Dr. Keith Rigby and Dr. James Baer who made suggestions regarding the mapping and structural interpretations; to Steven S. Oriel of the U.S. Geological Survey for his review of the map; to George Hampton of Amoco Production Company, for

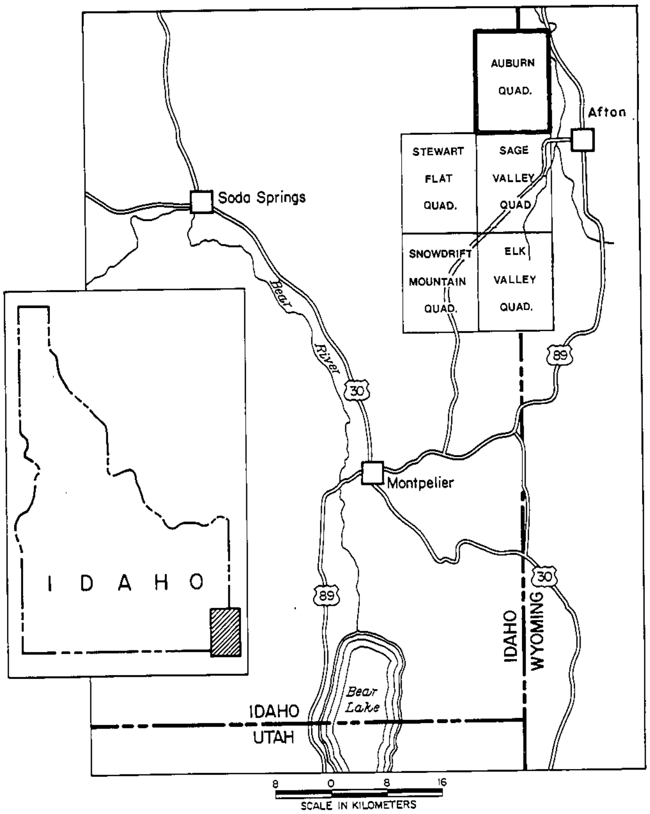

FIGURE 1.—Index map showing the location of the Auburn Quadrangle.

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*A thesis presented to the Department of Geology, Brigham Young University, in partial fulfillment of the requirements for the degree Master of Science, April 1981. Thesis chairman: Lehi F. Hintze.

his field assistance on several occasions; and to John Conner and Floyd Hatch, fellow graduate students who mapped nearby quadrangles, for their help and encouragement. Financial assistance was provided by Amoco Production Company, Marathon Oil Company, and Brigham Young University.

I would like to thank my father, Don Jenkins, and my father-in-law, Iver Hendrickson, for their field assistance and support. Sincere appreciation is extended to my wife, Ilene, for typing the many drafts of the manuscript, and for her support and encouragement.

STRATIGRAPHY

General Statement

Rocks in the Auburn Quadrangle range in age from Late Permian to Quaternary (fig. 2); Permian through Cretaceous strata form a series of northwestward-trending folds atop two thrust plates (plate 1). These strata are about 5,000 m thick (fig. 2). The Tertiary Salt Lake Formation, a fresh-water deposit which covers many low-lying areas in the quadrangle, was deposited after faulting and folding. Alluvium, travertine, and salt deposits are considered to be Quaternary.

Permian System

Phosphoria Formation

Rex Chert Member. The upper part of the Rex Chert Member of the Phosphoria Formation crops out in the core of the Hemmert Anticline, section 14, T. 33 N, R. 119 W (plate 1). There the Rex Chert-Dinwoody boundary is obscured, but the formations may be in fault contact. Regionally, the Rex Chert is overlain conformably by an unnamed cherty shale member of the Phosphoria Formation which was not observed in the Auburn Quadrangle. For a review of the Phosphoria Formation and its history of nomenclature, see Hatch (1980) and Conner (1980).

The Rex Chert forms a resistant ledge of massive, gray, granular to fine-grained, cherty limestone (fig. 3). Because the base is concealed, its thickness could not be determined, but 45 m was reported by Conner (1980) in the Sage Valley Quadrangle to the south (fig. 1).

Triassic System

Triassic rocks crop out on both the Absaroka and Meade thrust plates in the Auburn Quadrangle. Subdivision of Triassic rocks on the Meade plate followed usage of Hatch (1980), Conner (1980), and Mansfield (1927); those on the Absaroka plate followed (fig. 4) subdivisions used by Rubey and Hubbert (1958).

Dinwoody Formation

The Dinwoody Formation was named and defined by Blackwelder (1918, p. 425–26) from Dinwoody Canyon in the Wind River Mountains. For a stratigraphic review and history of its nomenclature, see Hatch (1980) or Conner (1980).

The Dinwoody Formation conformably overlies the Phosphoria Formation in the core of the Hemmert Anticline, sections 2, 3, 10, 11, T. 33 N, R. 119 W; its approximate thickness is 200 m. In the Auburn Quadrangle the formation consists of alternating thin layers of dull, greenish gray, calcareous siltstone and shale and argillaceous, sandy limestone that weather light brown to light gray. The Dinwoody is conformably overlain by redbeds of the Woodside Formation. The Dinwoody-Woodside boundary is obscure because of poor exposures but was placed at the boundary where float changes

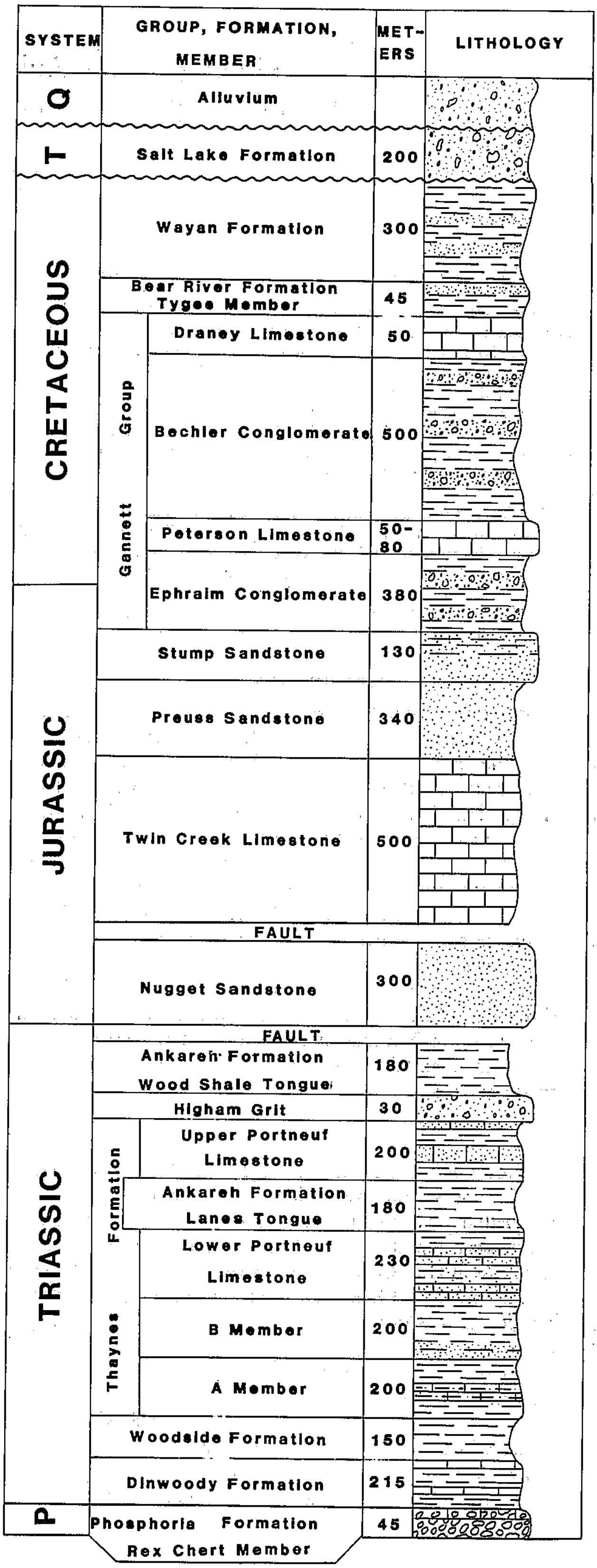

FIGURE 2.–Generalized stratigraphic relations of the Auburn Quadrangle.

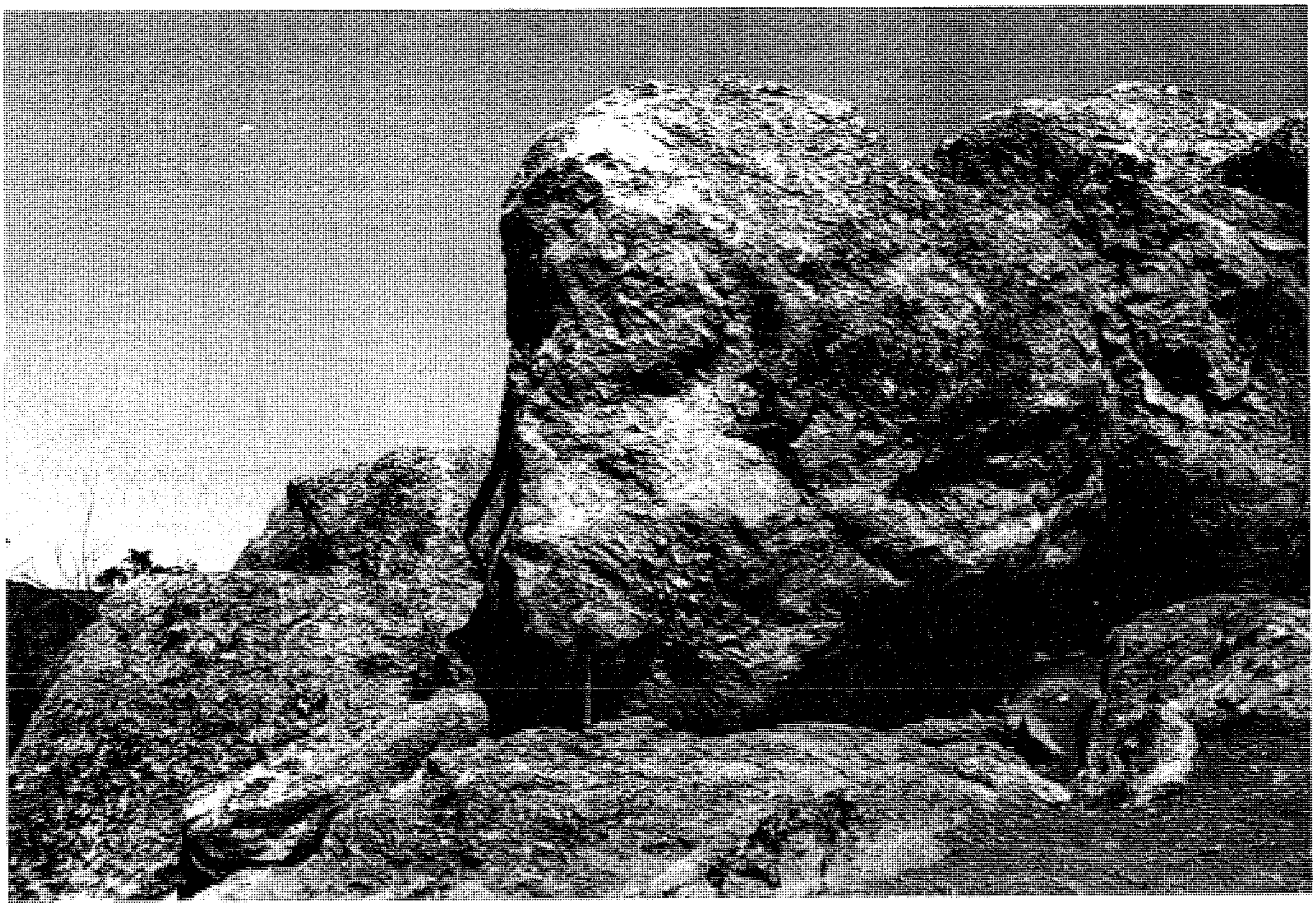

FIGURE 3.–Rex Chert Member of the Phosphoria Formation in section 14, T. 33 N, R. 119 W, Wyoming.

from a dull greenish brown siltstone and sandy limestone to predominantly red siltstone and shale.

Woodside Formation

The Woodside Formation was named by Boutwell (1907, p. 446) after Woodside Gulch in the Park City district of Utah. For a stratigraphic review and history of its nomenclature see Conner (1980).

The Woodside Formation is exposed along the flanks of the Hemmert Anticline in sections 2, 3, 10, 11, T. 33 N, R. 119 W, where it consists of nonresistant redbeds of siltstone and shale with a few thin beds of red sandstone and gray limestone. It is approximately 150 m thick and is overlain conformably by the lower member of the Thaynes Formation. The Woodside-Thaynes boundary was placed where the float changed from a reddish siltstone and shale to gray sandy limestone and greenish gray calcareous siltstone.

Thaynes Formation

The Thaynes Formation was named by Boutwell (1907, p. 448) from Thaynes Canyon near Park City, Utah. For a stratigraphic review and history of the nomenclature, see Cressman (1964), Hatch (1980), and Conner (1980).

The formation crops out on the flanks of the Hemmert Anticline, in the northeast corner, and in the southwest corner of the Auburn Quadrangle. These outcrop areas are on separate thrust plates, and, because they display considerable differences in lithology, they were mapped with different member divisions (fig. 4). On the Meade plate the members used followed Conner (1980) and Montgomery (1967). On the Absaroka plate the members used followed Rubey and Hubbert (1958).

Thaynes members of the Meade plate (fig. 2) are from oldest to youngest: A member, B member, Lower Portneuf Limestone, and Upper Portneuf Limestone. On the Absaroka plate the Thaynes is divided only into upper and lower members (fig. 4).

A Member. The A Member crops out in sections 5 and 6, T. 8 S, R. 46 E (plate 1). It is estimated to be 200 m thick (Con-

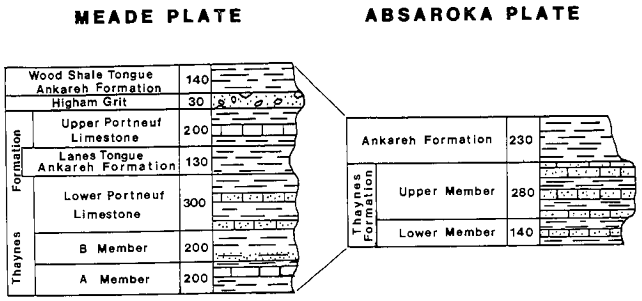

FIGURE 4.–Member divisions of the Thaynes and Ankareh Formations on the Meade and Absaroka plates.

ner 1980). As mapped the A member consists of a poorly exposed, nonresistant, slope-forming unit of thin-bedded, gray, calcareous mudstone and shaly limestone. The contact between the A member and the B member was placed at the base of a resistant ledge of thinly bedded, light brown, calcareous sandstone and shale. Ammonites are abundant throughout the A member in Webster Canyon (fig. 5). For a detailed discussion of these ammonites, see Conner (1980).

B Member. The B member of the Thaynes Formation is exposed in sections 5 and 6, T. 8 S, R. 46 E (plate 1). It is estimated to be 200 m thick (Montgomery and Cheney 1967). Within the Auburn Quadrangle the lower quarter of the B member consists of a resistant ledge of thinly bedded, light gray, calcareous sandstone and shale. The upper three quarters is poorly exposed, slope-forming, calcareous siltstone and sandy shale. The upper contact of the B member was placed at the base of the lowest medium-bedded limestone of the Lower Portneuf Limestone Member.

Portneuf Limestone Member. The Portneuf Limestone was named by Mansfield (1915, p. 492; 1916, p. 38) for exposures along Portneuf River in the Fort Hall Indian Reservation. In the Auburn Quadrangle the member is split into upper and lower parts by the Lanes Tongue of the Ankareh Formation.

The Lower Portneuf Limestone is exposed in sections 31 and 32, T. 7 S, R. 46 E. The dominant lithology consists of medium-bedded, gray limestone, interbedded with sandstone and siltstone. Many of the limestone beds contain fossil fragments of brachiopods and echinoid spines. The lower member of the Portneuf Limestone was reported by Conner (1980) to be 200 m thick. The anomalous-appearing thickness of this member in the Auburn Quadrangle is probably due to second order folding obscured by cover.

The Upper Portneuf Limestone Member is exposed in sections 19, 20, and 29, T. 7 S, R. 46 E. The dominant lithology is well-sorted, fine-grained quartz sandstone, with several thin units of sandy limestone interbedded with siltstone.

In conformity with the usage of Conner (1980) in the Sage Valley Quadrangle to the south, the Upper Portneuf Member was not mapped as the Timothy Sandstone Member as it was by Mansfield (1927). Its thickness is estimated to be 200 m. The basal contact of Upper Portneuf Limestone was placed at the top of the red shale and siltstone of the Lanes Tongue.

Lower Member of the Thaynes Formation. The lower member of the Thaynes Formation crops out in sections 2, 3 and 10, T. 33 N, R. 119 W, along the flanks of the Hemmert Anticline (plate 1). This member is a nonresistant, slope-forming unit composed of only a few thick-bedded limestone units alternating with calcareous, greenish gray siltstone and shale. Its estimated thickness is 140 m as reported by Rubey and Hubbert (1958). The basal contact was placed at the top of the redbeds in the Woodside Formation.

FIGURE 5.–Ammonites in the A member of the Thaynes Formation, in Webster Canyon, section 6, T. 8 S, R. 46 E, Idaho.

Upper Member of the Thaynes Formation. The upper member of the Thaynes Formation also crops out along the flanks of the Hemmert Anticline in sections 2 and 3, T. 33 N, R. 119 W (plate 1). This member forms ridges of alternating thick-bedded, light gray limestone and greenish gray, calcareous siltstone and shale. Rubey and Hubbert (1958) reported a thickness of 280 m in the Bedford Quadrangle.

Ankareh Formation

The Ankareh Formation was named by Boutwell (1907, p. 452) from Ankareh Ridge near Park City, Utah. In the Auburn Quadrangle the Ankareh Formation crops out on both the Meade and Absaroka plates. On the Meade plate the Ankareh is divided into two tongues, the Lanes Tongue and the Wood Shale Tongue, by the Upper Portneuf Limestone and the Higham Grit. On the Absaroka plate there are no member divisions of the Ankareh Formation (fig. 4).

Lanes Tongue of the Ankareh Formation. The Lanes Tongue, which crops out in sections 19 and 29, T. 7 S, R. 46 E, consists of reddish brown, fine-grained siltstone and shale. It is poorly exposed in the mapped area where it forms swales between the more resistant upper and lower Portneuf Limestone Members of the Thaynes Formation. It is approximately 180 m thick in the Auburn Quadrangle on the basis of map measurements.

Woodshale Tongue of the Ankareh Formation. The Wood Shale Tongue is exposed in sections 29 and 19, T. 7 S, R. 46 E (plate 1) and is similar to the Lanes Tongue in lithology and character. Its dominant lithology is red, well-laminated, calcareous siltstone and shale. There are a few rare, poorly exposed units of light gray limestone and dolomite, typical of Mansfield's (1927) Deadman Limestone. The apparently conformable contact with the underlying Upper Portneuf Limestone was mapped at the base of the red soil-covered slopes of the Wood Shale Tongue. Its thickness is 180 m on the basis of map measurements.

Ankareh Formation of the Absaroka Plate. The lower part of the Ankareh Formation is exposed along the flanks of the Hemmert Anticline in sections 2 and 3, T. 33 N, R. 119 W (plate 1), where the formation consists of well-laminated, red and purplish, calcareous shale and siltstone, with some sandy units. The Ankareh is estimated to be 230 m thick.

Higham Grit

The Higham Grit was named and defined by Mansfield (1927, p. 95) from the Fort Hall Indian Reservation. For a stratigraphic review and history of the nomenclature, see Kummel (1954).

In the Auburn Quadrangle the Higham Grit is exposed in sections 19 and 29, T. 7 S, R. 46 E, on the west flank of the Boulder Creek Anticline. It consists of a coarse white to pinkish, gritty or conglomeratic sandstone, with angular to subangular fragments of quartzite. The Higham Grit is about 40 m thick in the Auburn Quadrangle. It seems to conformably overlie the Upper Portneuf Limestone with the basal contact placed at the boundary between the reddish siltstone and the quartzite conglomerate.

Jurassic System

Jurassic rocks are exposed on both upper and lower thrust plates throughout the Auburn Quadrangle and include, from oldest to youngest, the Nugget Sandstone, Twin Creek Limestone, Preuss Sandstone, and Stump Sandstone. Jurassic rocks are approximately 1,300 m thick in the mapped area. For a stratigraphic review and history of nomenclature of these Jurassic Formations, see Hatch (1980) and Conner (1980).

Nugget Sandstone

The Nugget Sandstone was named by Veatch (1907, p. 56) from Nugget Railroad Station in southwestern Wyoming. The formation crops out on both the upper and lower plates within the quadrangle.

The Nugget consists of massive, orange pink and reddish orange to white, fine- to medium-grained, occasionally calcareous, quartz sandstone. Porosity seems to be minimal. Cross-bedding is common in sets up to 15 cm, but the predominant sedimentary structure is planar bedding laminations. The Nugget is a resistant formation forming ridges and mountain crests, typically covered with angular block talus. The formation is approximately 300 m thick as measured within the quadrangle (see appendix).

Twin Creek Limestone

The Twin Creek Limestone was named by Veatch (1907, p. 56) from Twin Creek in western Wyoming. In the Auburn Quadrangle the Twin Creek is exposed along the east flank of the Boulder Creek Anticline, along the west flank of the Spring Creek Syncline, in two locations, and in the northeast corner of the mapped area.

In the Auburn Quadrangle the Twin Creek distinctively consists of poorly exposed, medium to dark gray, shaly limestone that weathers to form light gray slopes covered with splintery float (fig. 6, 7). The lower part of the formation includes resistant interbeds of massive, light gray, blocky limestone. Its total thickness is about 500 m. A section was measured in the northeast corner of the quadrangle (see appendix). No fossils were observed in this formation during the present study. The Twin Creek-Nugget boundary was placed between the covered swales of the Twin Creek Limestone and the talus-covered ridges of the Nugget Sandstone.

Preuss Sandstone

The Preuss Sandstone conformably overlies Twin Creek Limestone within the Auburn Quadrangle. It was named by Mansfield and Roundy (1916, p. 81) for Preuss Creek, near Montpelier, Idaho. The Preuss Sandstone crops out on the east and west flanks of the Spring Creek Syncline and Miller Creek Syncline in the Auburn Quadrangle.

One partial and one full section of the Pruess Sandstone were measured within the quadrangle (see appendix), where it consists of rarely exposed, reddish brown, thinly bedded, fine-grained, calcareous, argillaceous sandstones, interbedded with

FIGURE 6.—Twin Creek Limestone in a roadcut in Stump Valley along the west flank of the Spring Creek Syncline.

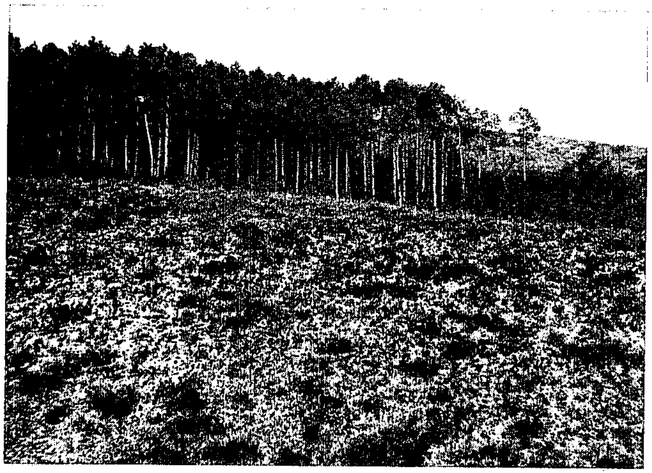

FIGURE 7.—Typical exposure of the Twin Creek Limestone in section 15, T. 33 N, R. 119 W, Wyoming.

pale red mudstones. A typical Preuss exposure is a rounded hill covered with red soil that contains sandstone ledges. There are abundant ripple marks and cross-bedding in the sandstones. The Preuss Sandstone is approximately 340 m thick within the mapped area.

Two wells were drilled in Tygee Valley within the Auburn Quadrangle (Hodgden and McDonald 1977, p. 57, 58), in SW¼, SW¼, section 34, T. 7 S, R. 46 E. Both wells encountered large salt-bearing sections within the Preuss Sandstone, up to 130 m. Pure salt beds range in thickness from 2 to 7 m. Several salt springs exist within the quadrangle in the Tygee and Stump Valleys. It is believed that the salt migrates up from the Preuss as a result of percolating groundwater along the planes of the thrust faults (see plate 1).

Stump Sandstone

The Stump Sandstone is apparently conformably underlain by the Preuss Sandstone and unconformably overlain by the Ephraim Conglomerate. The Stump Sandstone was named by Mansfield and Roundy (1916, p. 81) from Stump Peak, approximately 6.5 km northwest of the Auburn Quadrangle. The formation crops out in the quadrangle on both the east and the west flanks of the Spring Creek Syncline and along the west flank of the Miller Creek Syncline.

As it is exposed in the quadrangle, the formation consists of a lower, resistant, ledge-forming unit of medium to massively bedded, grayish olive, fine-grained, calcareous, glauconitic sandstone and an upper slope-forming unit of thin-bedded, calcareous sandstone interbedded with olive gray mudstone. Throughout the Stump Sandstone, cross-bedding is common, and ripple marks are seen in abundance in the upper units of the formation (figs. 8, 9). Three sections of the Stump Sandstone were measured within the quadrangle (see appendix). The thickness of the formation there ranges from 108 m to 124 m.

Cretaceous System

Cretaceous rocks crop out throughout the Auburn Quadrangle on the lower thrust plate. Six formations make up the Cretaceous System. The four lower formations, belonging to the Gannett Group, are the Ephraim Conglomerate, Peterson Limestone, Bechler Conglomerate, and Draney Limestone; all have complete sections within the quadrangle. The upper two formations, the Tygee member of the Bear River Formation and the Wayan Formation do not have complete sections exposed in the quadrangle. Cretaceous rocks are approximately 1,300 m thick in the mapped area (fig. 2). For a stratigraphic review and a history of its nomenclature, see Hatch (1980), Conner (1980), Randall (1960), and Eyer (1965).

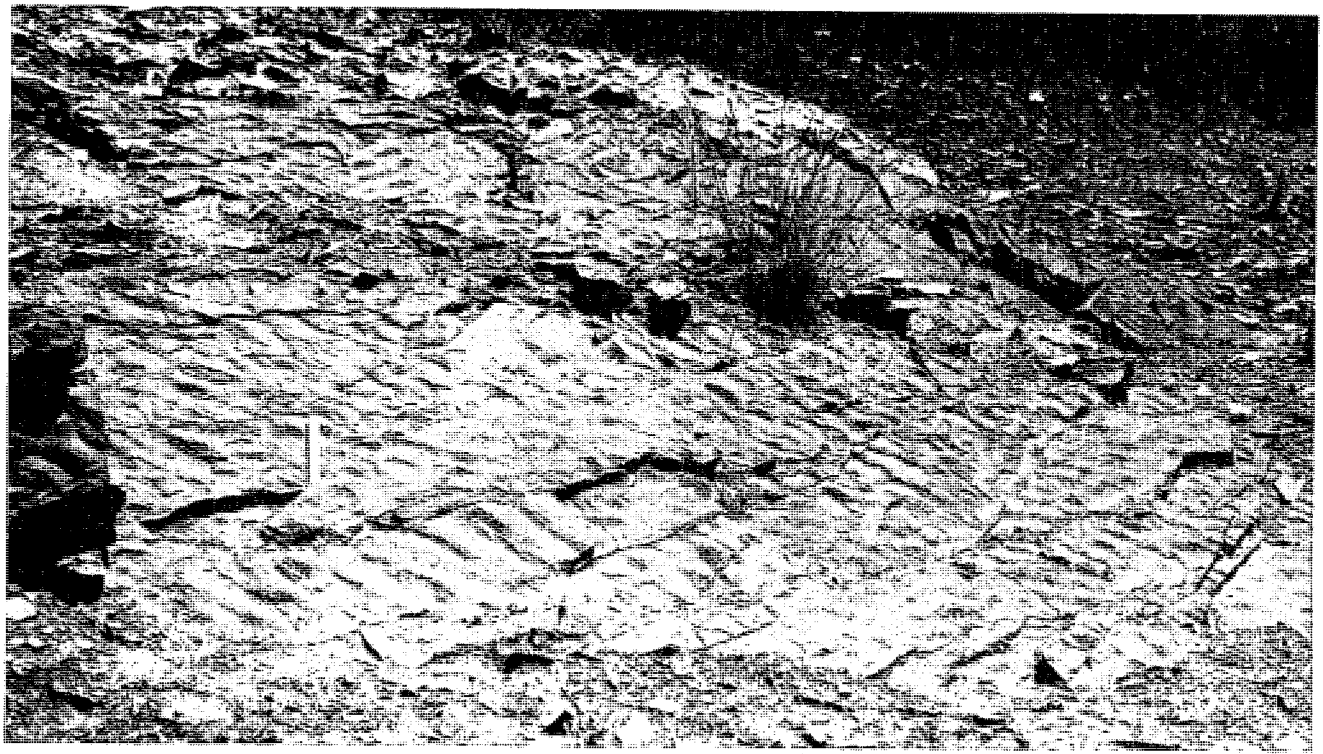

FIGURE 8.—Abundant ripple marks in lower units of the Stump Sandstone, section 34, T. 7 S, R. 46 E, Idaho.

Ephraim Conglomerate

The Ephraim Conglomerate was named by Mansfield and Roundy (1916, p. 82) from Ephraim Valley, 25 km south-southwest of Auburn, Wyoming. The formation occurs throughout the quadrangle where it crops out along the flanks of the Spring Creek Syncline and the Miller Creek Syncline. Two sections of the Ephraim Conglomerate were measured (see appendix). The thickness of the formation is estimated at 380 m.

As exposed, the Ephraim Conglomerate consists of slopes of reddish siltstone and shale with lentils up to 3 m thick of a conglomerate in a coarse-grained, poorly sorted, sandstone matrix and of persistent zones of light gray nodular limestone units up to 1 m thick. The pebbles in the conglomerate are rounded and composed of siltstone, limestone, sandstone, quartzite, and chert. These conglomerate units thicken and increase in number to the south and west (Conner 1980). In several areas slickensides were observed in the conglomeratic units of the Ephraim Conglomerate (fig. 10).

The basal contact of the Ephraim Conglomerate was mapped by a change in color of outcrops or float from the older, medium or olive gray Stump beds to the younger brownish red Ephraim beds above.

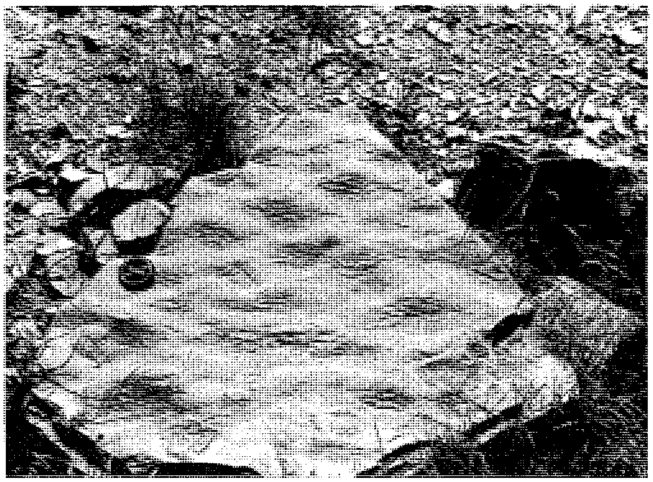

FIGURE 9.–More ripple marks in the same locality as those in figure 8.

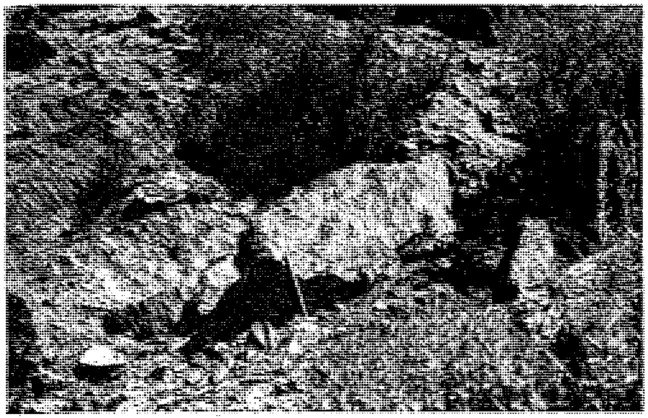

FIGURE 10.–Slickensides in a conglomerate unit of the Ephraim Conglomerate in section 16, T. 7 S, R. 46 E, Idaho.

Peterson Limestone

The Peterson Limestone is apparently conformably underlain by the Ephraim Conglomerate and conformably overlain by the Bechler Conglomerate. The Peterson Limestone was named by Mansfield and Roundy (1916, p. 82) from the Peterson Ranch in the Auburn Quadrangle, along Tygee Creek, in section 34, T. 7 S, R. 46 E, east of which the formation is well exposed. The formation is exceptionally well exposed in the study area with outcrops on the east and west flanks of the Spring Creek and Miller Creek Synclines. Three sections of the Peterson were measured in the study area (see appendix).

The Peterson Limestone is a conspicuous unit of medium to massively bedded, dark to light gray, blocky limestone with some interbeds of light gray calcareous shale. The formation forms prominent ridges that can be followed by the eye for miles (fig. 16). Its thickness within the quadrangle ranges from 40 m in the south to 63 m in the north. The formation continues to thin to the south down to 1 or 2 m in the Elk Valley Quadrangle (Hatch 1980).

Bechler Conglomerate

The Bechler Conglomerate overlies the Peterson Limestone and is exposed in the core of the Spring Creek and Miller Creek Synclines. In the Auburn Quadrangle the Bechler Conglomerate is similar in appearance to the Ephraim Conglomerate and forms low hills covered by reddish soil, with occasional outcrops of ledge-forming sandstone and conglomerate that become thicker and more prominent to the south and west (Conner 1980).

Conglomeratic units within the Bechler Conglomerate have a coarse-grained sandstone matrix, are commonly cross-bedded, and appear to be lenticular channel fillings that pinch out laterally. The cobbles in the conglomerate beds are rounded and composed of siltstone, sandstone, quartzite, and varicolored chert. Pebbles attain maximum diameters of about 15 to 20 cm in outcrops in the southern part of the Auburn Quadrangle. Interbeds of light gray nodular limestone that appear in both the Ephraim and Bechler Conglomerates seem to be more numerous in the Bechler. Its estimated thickness is 500 m. Only one complete section was measured in section 34, T. 7 S, R. 46 E, where it is 710 m thick. This anomalous thickness is probably due to faulting and second order folding obscured by poor exposures.

Draney Limestone

Outcrops of the Draney Limestone occur in two small areas within the Auburn Quadrangle, in the cores of the Miller Creek and Spring Creek Synclines (plate 1). The formation consists of relatively nonresistant calcareous, light gray siltstone, interbedded with dense gray limestone. It appears similar to the Peterson Limestone but is less resistant and forms low shoulders rather than prominent ledges. In the Auburn Quadrangle the Draney typically forms low hills covered by light gray soil with abundant light gray limestone float.

Tygee Member of the Bear River Formation

The Tygee Member of the Bear River Formation overlies the Draney Limestone and crops out in only one small area along the northern boundary of the mapped area in the core of the Miller Creek Syncline. The formation is characterized by a lower 40 m unit of weakly resistant, black, poorly exposed, thinly bedded shale, and an upper 5-m unit of quartz sandstone. The sandstone is very resistant, ledge forming, quartzitic, calcareous, greenish brown, iron stained, and cross-bedded (fig. 11).

FIGURE 11.–Upper sandstone unit of the Tygee Member of the Bear River Formation, west flank of the Miller Creek Syncline, section 27, T. 6 S, R. 46 E, Idaho.

Wayan Formation

The Wayan unconformably overlies the Bear River Formation and has a thickness of about 550 m (Mansfield 1927, p. 105). It is exposed in the Auburn Quadrangle in fault relationships between the Spring Creek and Miller Creek Synclines (plate 1). The Wayan Formation in the study area consists of interbedded sandstone and shale. The shales are rarely exposed, reddish-purple and calcareous. The sandstones are thin to medium bedded, medium- to coarse-grained, calcareous, poorly cemented, salt-and-pepper units 0.5 to 2 m thick. The formation forms low hills covered with reddish soil.

Tertiary System

Salt Lake Formation

The Paleozoic and Mesozoic rocks described earlier are separated by a profound unconformity from the Tertiary and Quaternary Rocks. The Salt Lake Formation was named by Hayden (1869, p. 92) from the Weber and Salt Lake Valleys of northern Utah. The Salt Lake Formation, a fresh-water, lacustrine deposit, covers a major portion of the low-lying areas in the Auburn Quadrangle. The formation is easily eroded and forms low hills (fig. 12) covered with light colored soil and occasional float fragments consisting of rounded pebbles originally derived from other formations.

Quaternary System

Alluvium of unknown thickness fills the valleys and canyons of Stump and Tygee Creeks and a major portion of Star Valley in the quadrangle around Auburn, Wyoming. Colluvium as mapped includes hill wash and talus and small landslides. No attempt was made to differentiate the relative ages of the Quaternary deposits.

Travertine patches are associated with active springs in three locations in the Auburn Quadrangle. Travertine in sections 14 and 23, T. 33 N, R. 119 W, is associated with an active hot springs just to the east of the mapped area in the Bedford Quadrangle (Rubey and Hubbert 1958). Travertine deposits occur in two locations in section 32, T. 7 S, R. 46 E (see plate 1); both are associated with cold springs.

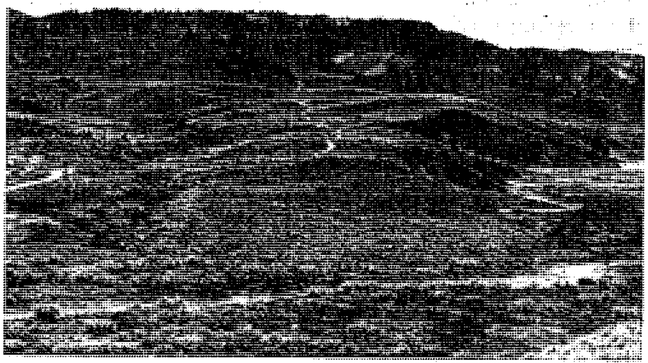

FIGURE 12.–Characteristic topography of the Salt Lake Formation in section 21, T. 7 S, R. 46 E, Idaho.

Several salt springs exist in the Stump and Tygee Valleys within the Auburn Quadrangle (fig. 13). Alignment of several salt springs within and near the Auburn Quadrangle seem to be controlled by traces of branches of the Meade thrust fault. The origin of this salt has been previously discussed in the Preuss Sandstone section.

STRUCTURE

General Statement

The Auburn Quadrangle is near the middle of the Overthrust Belt (fig. 14). Major structural elements in the quadrangle include three large-scale folds, numerous transverse faults, and the Meade Overthrust with its associated imbricate thrust. These structures have been overprinted by basin-and-range high-angle faulting. Interpretation of structures of the Auburn Quadrangle are shown in two structure sections, A–A′ and B–B′ of plate 1. This interpretation is similar to that of Royce, Warner, and Reese (1975). Their generalized cross sec-

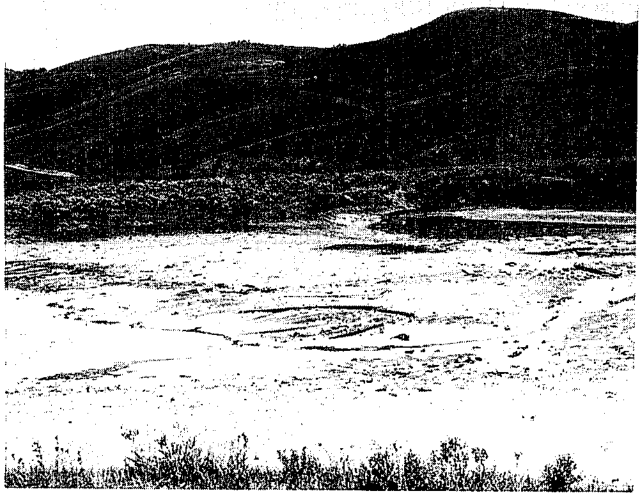

FIGURE 13.–Salt springs in Stump Valley; salt was mined here in the early 1900s.

tion X–X′ through the Auburn Quadrangle was used as a model for section A–A′ (plate 1).

Meade Thrust Fault

The major fault in the Auburn Quadrangle is the Meade Thrust which separates the area into the Meade and the Absaroka plates (fig. 14). This fault was originally termed the Bannock Thrust Fault by Richards and Mansfield (1912, p. 695), but was renamed the Meade Thrust Fault by Cressman (1964, p. 62).

In the Auburn Quadrangle the Meade Thrust Fault is not exposed but is expressed by salt springs in Stump and Tygee Valleys (plate 1). Imbricate thrust slices cut the footwall east of the principal Meade Thrust and also cut the hanging wall to the west (plate 1). The imbrications of the footwall are expressed by salt springs in the Stump and Tygee Valleys, by bed duplications, shortened sections, rapid changes in dip (fig. 15), and overturned beds along the west flank of the Spring Creek Syncline.

There are two main imbricate slices of the hanging wall. The first follows the west side of the Stump and Tygee Valleys and is covered by the Salt Lake Formation and alluvium. This slice extends from the Sage Valley Quadrangle (Conner 1980), where better evidence of imbrication exists, into the Auburn Quadrangle. The second slice also extends northward from the Sage Valley Quadrangle. No stratigraphic displacement is apparent on it in the Auburn Quadrangle, but its presence is indicated by overturned beds in the lower Twin Creek Limestone, section 20, T. 7 S, R. 46 E (plate 1).

The sole glide plane of the Meade Thrust Fault follows within the Twin Creek Limestone (Cressman 1964) until the thrust ramps sharply upward through Jurassic and Cretaceous strata (plate 1, sections A–A′ and B–B′). The age of the thrusting cannot be accurately determined from relationships within the quadrangle, but it is surely post-Wayan Formation (late Early Cretaceous) and pre-Salt Lake Formation (Pliocene). Rubey and Hubbert (1958) concluded that movement on the Meade Thrust Fault was initiated at the end of the Early Cretaceous and continued until the end of Late Cretaceous, or possibly Paleocene.

Faults

Tear Faults

One fault, in about the center of the Auburn Quadrangle, offsets both limbs of the Spring Creek Syncline (plate 1). It is a left lateral tear fault with about 150 m of displacement. The fault trends roughly N 60 E and is 2 km long.

Transverse Faults

Numerous faults that cut transversely across the principal structures trend between N 50 E and N 30 E (plate 1). From map patterns these faults seem to be high angle. No evidence was found which conclusively shows dip-slip or strike-slip motion along these faults. Since the faults did not show displacement across both limbs of folds and because slickensides were not observed in place, they are designated here as transverse faults, but because of their orientation, the likelihood is that they are tear faults.

North-South High-Angle Faults

Seven north-south-trending, high-angle, normal, and reverse faults are shown on section A–A′ (plate 1). Three of these faults have map patterns which indicate an eastward dip. However, no evidence was found for the other faults that shows whether they dip steeply eastward, vertically, or westward. Eastward dips agree with those shown by Royce, Warner, and Reese (1975) who refer to these high-angle, east-dipping, reverse faults (A–A′, plate 1) as back thrusts.

Movement along these faults is believed to be associated with basin-and-range faulting which occurred from Miocene to Recent (Armstrong and Oriel 1965). There is no evidence of Recent movement of these faults in the Auburn Quadrangle. However, north-south normal faulting in the Bedford Quadrangle to the east has displaced Recent alluvium between 10 and 12 m according to Rubey and Hubbert (1958). On June 12, 1930, a fairly strong earthquake shock was felt at Auburn, and aftershocks continued there through November 16 of that year (Neumann and Bodle 1932, p. 7).

In the following paragraphs the north-south-trending, high-angle faults are discussed from east to west (section A–A′, plate 1). The Hemmert Fault parallels the axis of the Hemmert Anticline (plate 1). The fault lies principally within the Dinwoody Formation and is not readily distinguishable. However, toward the south end of the anticline, in section 14, T. 33 N, R. 119 W, the Rex Chert is apparently faulted against the Dinwoody. In section 23, T. 33 N, R. 119 W, travertine deposits occur at sulphur springs along the trace of the fault. Stratigraphic throw on the fault is probably less than 100 m.

About 1.5 km to the west and paralleling the Hemmert Fault is the Freedom Fault, named by Mansfield (1927). The Freedom Fault is a high-angle reverse fault which is downthrown on the west (section A–A′ and plate 1). Its stratigraphic throw is estimated at 700 m. Mansfield (1927), suggested that the Freedom Fault curves to the east and joins the Hemmert Fault at the Auburn Hot Springs, section 14, T. 33 N, R. 119 W; however, I saw no evidence for this suggestion.

Two reverse faults break the Miller Creek Syncline on both the east and west sides (plate 1, section A–A′). The fault along the east side places Jurassic Preuss next to Cretaceous Ephraim Conglomerate with a stratigraphic throw of about 140 m. The fault along the west side of the syncline is downthrown to the west, placing the Cretaceous Wayan next to the Jurassic Preuss and Stump Formations (plate 1). Displacement along the fault shows an increase from about 1,000 m on the north to about 1,300 m in the south. To the south the fault trace trends into alluvium and colluvium and is probably more continuous than shown.

The Schiess Creek Fault, named by Mansfield (1927), generally parallels the Miller Creek Fault to the east. It is a normal fault downdropped on the east side, running parallel to and along the east flank of the Spring Creek Syncline. The fault has a stratigraphic throw which increases from approximately 700 m in the north, where Cretaceous Wayan is faulted against Cretaceous Ephraim Conglomerate, to approximately 1,300 m in the south where Cretaceous Wayan is faulted against Jurassic Preuss.

Two other unnamed high-angle reverse faults are just to the west of the Schiess Creek Fault, cutting the Spring Creek Syncline (section A–A′, plate 1). Both are downthrown on the east side and have stratigraphic displacements of less than 200 m.

Folds

Folding in the Auburn Quadrangle is believed to be contemporaneous with the thrusting. This conclusion agrees with other major studies done previously by Rubey (1958), Cressman (1964), Montgomery and Cheney (1967), and Conner (1980). The model of concentric folding proposed by Royce,

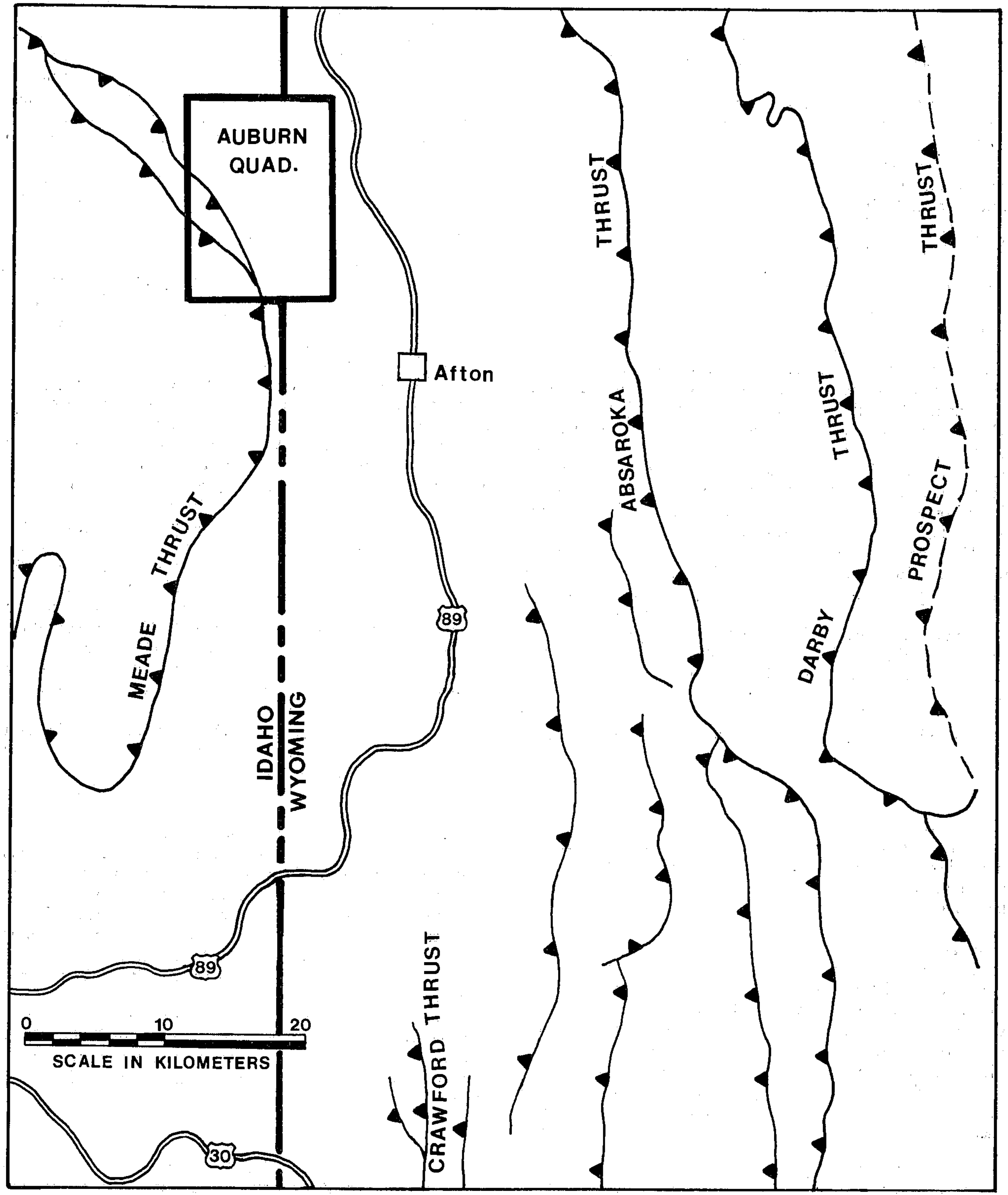

FIGURE 14.–Meade Thrust Fault and its relation to other thrust faults in southeast Idaho–western Wyoming.

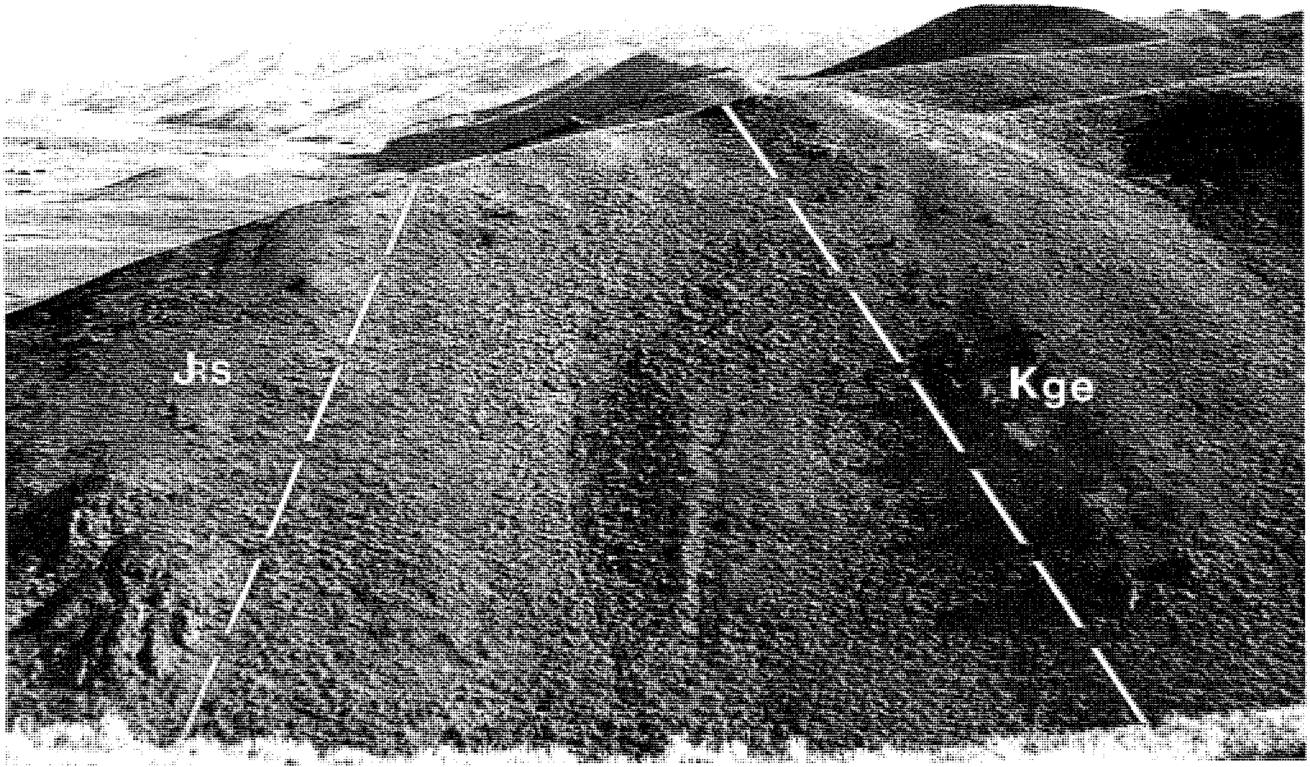

FIGURE 15.–Faulting is expressed by rapid change in dip of beds on the west flank of the Spring Creek Syncline, SE ¼, section 34, T. 7 S, R. 46 E, Idaho.

Warner, and Rees (1975) was used in drafting the structure sections A–A′ and B–B′ (plate 1). The three major folds mapped in the Auburn Quadrangle are all on the lower Absaroka Plate. The folded units in the southwest corner of the Auburn Quadrangle are on the east flanks of the Boulder Creek Anticline. For discussions on the Boulder Creek Anticline see Mansfield (1927) and Conner (1980). In the following paragraphs the individual folds are discussed from east to west.

The Hemmert Anticline trends north-south and is located in the northeast quarter of section T. 33 N, R. 119 W. The structure is symmetrical and plunges northward (section A–A′, plate 1). The beds exposed are all Triassic except for a small sliver of Rex Chert at the southern end of the anticline.

The Miller Creek Syncline trends north-northwest straddling the Idaho-Wyoming border (plate 1). The structure is cut on both sides by north-south-trending faults previously discussed. The Tygee Member of the Bear River Formation is the youngest unit exposed in the Miller Creek Syncline in the Auburn Quadrangle. A cross section through the syncline shows the structure as asymmetrical, with the axial surface of the fold dipping to the west (secton A–A′, plate 1). This pattern is typical for structures in the area (Rubey 1958).

The Spring Creek Syncline is the southeastward extension of the South Fork Synclinorium (Mansfield 1927). The fold trends north-northwest and is exposed the entire length of the quadrangle (fig. 16). The structure does not appear to plunge in either direction within the quadrangle. It is asymmetrical with west dips averaging 60° and east dips averaging 45° (plate 1). The axial plane, like the axial plane of Miller Creek Syncline, dips slightly to the west (section A–A′, plate 1). Within the Auburn Quadrangle the youngest formation exposed in the Spring Creek Syncline is the Draney Limestone. The syncline is offset in sections 10 and 15, T. 7 S, R. 46 E, by a small reverse fault previously discussed.

ECONOMIC GEOLOGY

Petroleum

Hodgden and McDonald (1977) reported several test wells drilled in the vicinity of the Auburn Quadrangle. Two shallow wells were drilled within the quadrangle, in Tygee Valley, section 34, T. 7 S, R. 46 E. The first well, drilled in 1922, reached a TD of 694 feet, bottoming in the Preuss Formation. This Preuss section consisted of interbedded shale and salt. Shows of oil were recovered in a "lime" at the bottom of the hole from 634 feet to the 694 foot TD. The second well, drilled in 1927, was a reentry (into the same hole because of the oil shows) and deepened it to 2,641 feet. Several shows of oil were reported. Interbedded salt and shale dominated the hole with the last 35 feet being in sandstone.

Major discoveries in the Overthrust Belt within the last five years have renewed exploration interest in the area. During the summer of 1980, several seismic crews worked near the Auburn Quadrangle, and several test wells were being drilled nearby.

Within the Auburn Quadrangle there are no Jurassic reservoir rocks thrust over Cretaceous source rocks as is the case at Pineview and Ryckman Creek fields. However, probably source rocks do exist in the Triassic Thaynes and Permian Phosphoria Formations and are in close proximity to the Jurassic Nugget Sandstone and Twin Creek Limestone reservoir rocks. Hydrocarbon exploration should be continued in the Auburn Quadrangle on folds associated with the ramping of the Meade Thrust. Also, it may be warranted to explore below the Absaroka plate within the quadrangle.

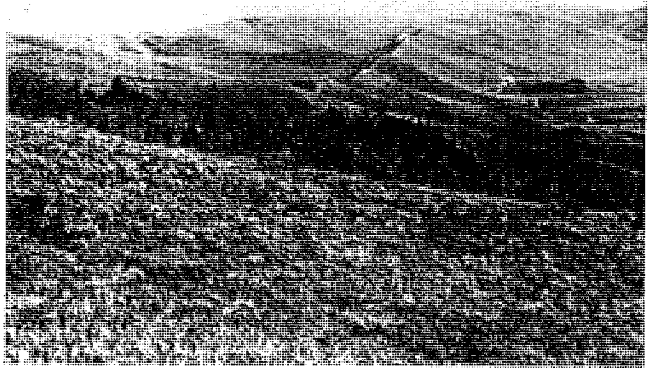

FIGURE 16.–Looking south along the Spring Creek Syncline. Resistant ridges are formed by the Peterson Limestone.

Phosphate

Phosphatic rocks were known in the areas surrounding the Auburn Quadrangle since 1906 (Weeks and Ferrier 1907). Mansfield (1927) evaluated the phosphate deposits of southeastern Idaho. Abundant phosphate reserves exist in the Meade Peak Member of the Phosphoria Formation in areas south of the Auburn Quadrangle (Cressman 1964). However, in the Auburn Quadrangle the phosphate potential is low because the Meade Peak Member is not exposed, and the overburden would be too thick to remove economically.

Hot Springs

A small group of hot springs exist 4 km north of the town of Auburn (fig. 17) in section 23, T. 33 N, R. 119 W, just east of the Auburn Quadrangle, and form the travertine deposits in section 23. Discharge from these springs ranges in temperature from 20 to 60° C, with subsurface temperatures in the range 90–150° C (Hinckley and Breckenridge 1977). This range is not generally considered sufficient for electrical generation under present technology but may provide substantial energy to a wide variety of industrial, agricultural, and domestic processes.

Little development has taken place at the Auburn Hot Springs. From 1947 to 1949 about 900 tons of sulfur were dug from this deposit and shipped for agricultural use. The spring is now used only to heat a small swimming pool.

Other Deposits

Several salt springs exist in the Stump and Tygee Valleys within the Auburn Quadrangle. The largest is in section 21, T. 7 S, R. 46 E (fig. 13); here salt was mined commercially in the early 1900s and sold for $10.00 per ton (Mansfield 1927, p. 339). No salt is presently produced within the quadrangle.

Sand and gravel from Tertiary and younger rocks may be developed in several places for construction purposes. Also, road metal in the Twin Creek Limestone and Stump Sandstone could be quarried from a few sites in the quadrangle. If population and industry develop in the area to the extent that the manufacture of portland cement is economical, some Twin Creek Limestone exposed within the quadrangle probably meets the specifications of cement rock (Mansfield 1927, p. 331, 334).

SUMMARY

The Auburn Quadrangle is divided into an upper Meade plate and a lower Absaroka plate by the Meade thrust. The principal Meade thrust and imbrications of both the footwall and hanging wall are expressed by salt springs, bed duplications, shortened sections, and overturned beds. Thrusting and contemporaneous folding are overprinted by north-south high-angle basin-and-range faulting.

FIGURE 17.–Active spring at the Auburn Hot Springs just east of the Auburn Quadrangle in section 23, T. 33 N, R. 119 W, Wyoming.

Approximately 5,000 m of sedimentary rocks are exposed within the quadrangle. On the Meade plate formations exposed range from Triassic Thaynes Formation through Jurassic Preuss Sandstone. On the Absaroka plate formations exposed range from Permian Rex Chert through Cretaceous Wayan Formation. On both plates major portions of the low-lying areas are covered by the Tertiary Salt Lake Formation which was deposited after faulting and folding. A revised stratigraphic nomenclature for southeastern Idaho and western Wyoming was successfully applied in the mapped area clarifying some inconsistencies present in previously published works.

Two oil wells were drilled in Tygee Valley in the 1920s. Shows of oil and gas were reported from both. I feel that because the area has a favorable geologic history and stratigraphy, several structural traps are possible and invite seismic investigation and testing with the drill bit.

APPENDIX

Measured Sections

Section 1

Partial section of the Preuss Sandstone and Stump Sandstone, measured on the east flank of the Spring Creek Syncline, NE ¼, section 33, T. 33 N, R. 119 W, Lincoln County, Wyoming and NW ¼, section 23, T. 7 S, R. 46 E, Caribou County, Idaho.

		Thickness (meters)	
Stump Sandstone		*Unit*	*Cumulative Section*
Unit			
11	Covered: gray green soil, occasional sandstone float, gray to greenish gray, weathers light brownish gray, fine to medium grained with some calcareous cementing, thinly laminated. Contact with overlying Ephraim Conglomerate located at disappearance of green soil.	25.4	315.2
10	Covered: same as Unit 11 only sandstone float is more abundant with much of it cross-laminated and blocky.	40.3	289.8
9	Sandstone and siltstone: alternating slopes and thin ledges, three sandstone ledges 0.7 m thick,	26.5	249.5

	blocky, dark gray, weathers light gray brown, thin medium bedded, glauconitic, medium to fine grained, cross-bedding abundant with some thin laminations, some poorly preserved ripple marks, calcareous. Unit capped by a 1.5-m-thick sandstone. Siltstone interbeds are medium gray, friable, thinly laminated, calcareous, form slope.		
8	Covered slope: similar to unit 4.	14.2	223
7	Siltstone: capped with a 2-m sandstone, siltstone; light reddish gray, weathers light gray, sandy, slope former, friable, calcareous, thinly laminated, flaggy, covered with sandstone float; sandstone; medium gray, weathers olive gray, medium bedded, thin laminations with some cross-bedding, abundant ripple marks, glauconitic, calcareous unit forms a swale, ledge former.	8.2	208.8
6	Sandstone: dark gray, weathers grayish olive, medium to thick bedded, blocky, medium to fine grained, poorly sorted, glauconitic, ripple marked, cross-bedded, lower part cross-bed sets up to 2 cm, upper section cross-bed sets up to 4 cm, calcareous, ledge former.	9	200.6
	Total thickness of Stump Sandstone	123.6 m	

Preuss Sandstone

5	Covered slope: brownish red soil, abundant sandstone float of Stump Sandstone, some siltstone—thinly laminated, calcareous; contact with overlying Stump Sandstone located at disappearance of red soil.	36	191.6
4	Covered slope: red soil, sandstone float, grayish red, weathers pinkish gray, fine to medium grained, moderately well sorted, indistinctly laminated, calcareous.	21.2	155.6
3	Sandstone and siltstone interbedded; sandstone: a few thin ledges, pale red, weathers reddish brown, 15–30 cm thick, thinly bedded, fine grained, well sorted, thin laminations, flaggy, calcareous; siltstone: pale reddish brown, calcareous.	61.4	134.4
2	Same as unit 3 except thin sandstone ledges become more numerous.	60.8	73
1	Covered slope: brownish red soil; some sandstone float, sandstone; pale red, weathers same, fine grained, well sorted, friable, calcareous; fault contact with the Wayan Formation.	12.2	12.2
	Total thickness of Preuss Sandstone	196.6 m	

Section 2

Section of Stump Sandstone and Gannett Group (Ephraim Conglomerate, Peterson Limestone, Bechler Conglomerate) measured on the west flank of the Spring Creek Syncline east of the old schoolhouse, S ½, section 34, T. 7 S, R. 46 E, Caribou County, Idaho.

Bechler Conglomerate

Unit		*Thickness (meters)* *Unit*	*Cumulative Section*
33	Covered slope: red soil. Contact with overlying Draney Limestone located at disappearance of red soil and appearance of gray soil and limestone float.	70.8	1261
32	Sandstone: ledge former, light to medium gray, weathers medium gray, thick bedded, coarse grained, poorly sorted, subangular to rounded, cross-bedded, calcareous.	3	1190.2
31	Covered slope: similar to unit 33.	23.6	1187.2
30	Conglomerate and siltstone: several conglomerate lenses in mudstone slope; conglomerate; pebbles up to 1.5 cm, and coarse-grained sandstone lenses up to 15 cm thick and 35 cm long; siltstone: pale red, calcareous.	12.6	1163.6
29	Conglomerate and sandstone: interlaced lenses of sandstone and conglomerate, ledge former; sandstone; medium gray brown, weathers medium gray, occurs in lenses, cross-bedded, medium to coarse grained, poorly sorted, calcareous; conglomerate; medium gray brown, weathers olive gray, up to 50% pebbles up to 3 cm in diameter, forms lenticular bodies with coarse-grained sandstone matrix, calcareous.	5.1	1151
28	Covered: reddish soil.	8.7	1145.9
27	Conglomerate and sandstone: similar to unit 30.	4.6	1137.2
26	Covered: reddish soil.	168.3	1132.6
25	Conglomerate: similar to unit 29.	3.4	964.3
24	Covered: reddish soil.	155.8	960.9
23	Sandstone: gray red purple, weathers grayish red, thick bedded, coarse grained, abundant quartz, poorly sorted, well indurated, calcareous, ledge former.	.6	805.1
22	Covered: reddish soil.	20.5	804.5
21	Covered: reddish soil.	219.2	784
20	Conglomerate and sandstone; conglomerate: light to medium gray, up to 60% pebbles up to 8 cm in diameter, subangular to well-rounded, coarse-grained sand matrix, poorly sorted, forms lenticular bodies, occasionally calcareous, ledge former; sandstone: coarse to medium grained, poorly sorted, subangular to rounded, cross-bedding, several lenses in conglomerate and dominate at the base of unit.	6.6	564.8
19	Covered slope: red soil with some sandstone float, very light gray, weathers medium gray, thin bedded, medium grained, abundant quartz, flaggy, well indurated, some cross-bedding, calcareous.	8.8	558.2
	Total thickness of Bechler Conglomerate	711.6 m	

Peterson Limestone

18	Covered: brownish red soil; limestone float, medium gray, weathers yellow gray, shaly, some fossil fragments seen, slope former; contact with overlying Bechler Conglomerate located at disappearance of light gray limestone float.	25.3	549.4
17	Limestone: olive gray, weathers medium gray, massive to thick bedded, blocky, microcrystalline, abundant fossil fragments, ledge former.	13.1	524.1
	Total thickness of Peterson Limestone	38.4 m	

Ephraim Conglomerate

16	Covered slope: pale red, float covered with gray limestone from the Peterson Limestone above, and coarse sandstone conglomerate; gray red purple, weathers grayish red, conglomerate up to 1 cm, subangular to rounded, thinly laminated, calcareous; contact with overlying Peterson Limestone located at top of purplish gray sandstone float.	196.7	511
15	Sandstone and limestone interbedded; sandstone: thin bedded, poorly exposed, thinly laminated, fine to medium grained, poorly sorted, friable, calcareous, forms slope; limestone: gray red purple, weathers grayish red, nodular, only two limestone beds within the unit, each 10 cm thick, microcrystalline, forms shoulder, no fossils.	7	314.3
14	Covered slope: pale reddish soil; abundant sandstone float, coarse grained, poorly sorted, ripple marked, calcareous.	42.5	307.3
13	Covered: similar to unit 16.	48.5	264.8
12	Limestone and siltstone interbedded; limestone: dark gray, weathers light medium gray, fist-size nodes exposed at surface, no bedding visible, abundant calcite stringers; unit forms a shoulder.	11.4	216.3
11	Covered slope: moderate reddish orange soil.	34.6	204.9
10	Sandstone: pale pink, weathers moderate brown, medium to coarse grained, poorly sorted, thick bedded, blocky, cross-bedded, cross-bed sets up to 4 cm, noncalcareous, ledge former.	9.4	170.3
9	Covered slope: conglomerate lenses and abundant coarse-grained sandstone float, upper 2 m is a ledge of conglomerate with pebbles up to 4 cm, calcareous, capped by a 1.2 m of sandstone, coarse	21.5	160.9

	to fine grained, poorly sorted, thick bedded, blocky, noncalcareous.		
8	Covered slope: pale reddish soil; abundant conglomerate and sandstone float as described in unit 9.	16.7	139.4
	Total thickness of Ephraim Conglomerate	388.3 m	
	Stump Sandstone		
7	Sandstone and siltstone: alternating slopes and ledges up to 1.5 m in thickness; sandstone: medium blue gray, weathers light olive gray, poorly exposed, fine grained, well sorted, argillaceous, calcareous, ledge former; siltstone: very poorly exposed, light gray red, calcareous, unit forms slopes; contact with overlying Ephraim Conglomerate located at disappearance of green soil.	14.4	122.7
6	Sandstone: dark greenish gray, weathers light olive gray, thin bedding, silty, poorly preserved ripple marks, glauconitic, fine to very fine grained, forms shoulder.	14	108.3
5	Sandstone: similar to unit 6, except this unit is capped by 0.5-m bed of sandstone, medium bedded, more resistant, fine to medium grained with some cross-bedding, ledge former.	27.4	94.3
4	Sandstone: greenish gray, weathers light olive gray, thin to very thin bedded, fine to medium grained, some cross-bedding, abundant glauconite, calcareous, ledge former.	11.7	66.9
3	Sandstone: similar to unit 4, only forms a shoulder, silty, less resistant, calcareous.	27.3	55.2
2	Sandstone: greenish gray, weathers light olive gray, thick bedded, cross-bedded, ripple marked, medium to fine grained, well indurated, calcareous, ledge former.	4.4	27.9
1	Sandstone and siltstone interbedded; sandstone: greenish gray, weathers light olive gray, poorly exposed, medium to thin bedded, glauconitic, occasional lenses of siltstone within sandstone, well indurated, medium grained, well sorted; siltstone: light brown gray, very rarely exposed, covered by abundant sandstone float, calcareous; contact with the underlying Preuss Sandstone located at the appearance of red soil.	23.5	23.5
	Total thickness of Stump Sandstone	122.7 m	

Section 3

Partial section of Gannett Group (Ephraim Conglomerate and Peterson Limestone) measured on the east flank of the Spring Creek Syncline, NW ¼, section 23, and NE ¼, section 22, T. 7 S, R. 46 E, Caribou County, Idaho.

Peterson Limestone Unit		*Thickness (meters)* Unit	*Cumulative Section*
23	Limestone: olive gray, weathers very light gray, medium to thick bedded, some fossil fragments seen, ledge former; contact with overlying Bechler Conglomerate is located at top of last ledge-forming limestone of the Peterson Limestone.	3.3	533.4
22	Limestone: same colors as unit 23, thin to very thin bedded, shaly, microcrystalline, forms a shoulder.	6.3	530.1
21	Limestone: light olive gray, weathers very light gray, very thin bedded, friable, argillaceous, slope former.	2.8	523.8
20	Limestone: similar to unit 23.	3.4	521
19	Limestone: simliar to unit 22, except color is light gray brown, weathers same.	5.3	517.6
18	Limestone: similar to unit 21.	4.5	512.3
17	Limestone: light gray, weathers light gray, medium bedded, blocky, microcrystalline, some fossil fragments seen, forms shoulder; contact with underlying Ephraim Conglomerate located at top of purplish gray soil.	2.8	507.8
	Total thickness of Peterson Limestone	28.4 m	
	Ephraim Conglomerate		
16	Covered slope: pale red soil, with abundant limestone float from above units.	62	505
15	Covered slope: similar to unit 16, except some sandstone float; coarse grained, poorly sorted, abundant quartz.	8.7	443
14	Covered: pale red soil. Similar to unit 16.	19.1	434.3
13	Sandstone and siltstone interbedded; sandstone: light gray, weathers medium gray, medium bedded, coarse grained, occasional cross-bed sets 1–3 cm, calcareous; siltstone: sandy, friable, calcareous, shoulder former.	10.3	415.2
12	Covered: similar to unit 16.	15.3	404.9
11	Sandstone and siltstone: similar to unit 13.	9.4	389.6
10	Covered: similar to unit 16.	113.8	380.2
9	Limestone: medium light gray, weathers light gray, nodular, well indurated, abundant calcite stringers, nodules 3–20 cm, microcrystalline.	1	266.4
8	Covered: similar to unit 16.	32.2	265.4
7	Limestone: nodular, similar to unit 9.	2.3	233.2
6	Covered: similar to unit 16.	8.4	230.9
5	Sandstone: gray red, weathers same, thinly bedded, some cross-bedding, medium grained, well sorted, argillaceous, well cemented, only a little calcareous, forms a shoulder.	5.2	222.5
4	Covered: similar to unit 16.	150	217.3
3	Conglomerate and sandstone interbedded: conglomerate: light gray, weathers medium dark gray, pebbles up to 1 cm, subangular to rounded, well cemented, noncalcareous; sandstone: occasional interbeds of coarse-grained sandstone, thinly laminated, poorly sorted, shoulder former.	14.2	67.3
2	Covered: similar to unit 16, except abundant conglomerate float similar to conglomerate in unit 3.	45	51.3
1	Covered slope: similar to unit 16, capped by several small 1-m conglomerate lenses (similar to conglomerate in unit 3) which pinch out laterally in both directions. Contact with underlying Stump Sandstone located at appearance of light gray green glauconitic sandstone float and light olive soil.	8.1	8.1
	Total thickness of Ephraim Conglomerate	505 m	

Section 4

Partial section of Nugget Sandstone and Twin Creek Limestone measured in N ½, section 15, T. 33 N, R. 119 W, Lincoln County, Wyoming.

Twin Creek Limestone Unit		*Thickness (meters)* Unit	*Cumulative Section*
20	Limestone: medium gray, weathers light gray, thin to medium bedding, silty, forms a shoulder; faulted against Wayan Formation, contact located at boundary between silty limestone and brownish red siltstone.	8.4	657.4
19	Covered slope: medium gray, weathers light gray, abundant limestone float, thin to very thin bedded, silty, a few 4–6-cm calcareous sandstone within unit.	237.8	649
18	Limestone: alternating ledges and slopes; slopes: medium gray, weather light gray, fissile, silty, microcrystalline, thin to very thin bedded; ledges: medium to thick bedded, blocky, microcrystalline, very resistant.	16.2	411.2
17	Limestone: dark gray, weathers medium gray, microcrystalline, blocky, no fossils seen, ledge former.	33.4	395
16	Limestone: alternating ledge and slope; slope: splintery, olive gray, weathers very light gray, silty; ledge: same color, medium bedded, microcrystalline, well indurated, two 1.5-m beds within unit.	58.6	361.6

15	Limestone: olive gray, weathers very light gray, thick to massively bedded, blocky, microcrystalline, ledge former.	.6	303
14	Covered slope: olive gray, weathers very light gray, abundant limestone float, shaly, splintery.	38.6	302.4
13	Limestone: medium gray, weathers light gray, poorly exposed, slope former, thinly bedded, shaly.	16.7	263.8
12	Limestone: dark yellow brown, weathers moderate yellow brown, very muddy, looks like a sandstone, thick bedded, blocky.	1.6	247.1
11	Limestone: similar to unit 13.	5	245.5
10	Limestone: similar to unit 12.	.9	240.5
9	Limestone: similar to unit 13.	8.6	239.6
8	Limestone: poorly exposed, mostly float covered; abundant fossil fragments, mollusks, crinoids; thin bedded, abundant calcite stringers, microcrystalline; contact with underlying Nugget Sandstone located at the top of the massively cross-bedded sandstone.	20.4	231
	Total thickness of Twin Creek Limestone	446.8 m	

Nugget Sandstone			
7	Covered: swale between Nugget and Twin Creek covered with sandstone float, medium grained, well sorted, noncalcareous, abundant quartz.	41.1	210.6
6	Sandstone: grayish orange pink, weathers to a pale red, medium bedded, thin laminations, abundant quartz, cross-bedding, medium grained, well sorted, some trace fossils, noncalcareous, ledge former.	10.8	169.5
5	Sandstone: orange pink, weathers pale red, thinly bedded, matchbox weathered appearance, argillaceous, medium grained, well rounded, noncalcareous, ledge former.	18.7	158.7
4	Sandstone: same color as unit 5, more resistant, medium to thick bedded, cross-bedding abundant, 80% quartz, well sorted, ledge former.	36.9	140
3	Sandstone: pale pink, weathers pale red, medium bedded, cross-bedding, abundant quartz, medium grained, well sorted, noncalcareous, shoulder former.	43.9	103.1
2	Sandstone: pale pink, weathers pale red, medium bedded, medium to fine grained, no cross-bedding, blocky, noncalcareous, ledge former.	35.3	59.2
1	Sandstone: grayish orange pink, weathers to a pale red, medium to fine grained, well sorted, blocky, sometimes a cliff former, noncalcareous, no cross-bedding, ledge former; faulted against nonresistant shales and siltstones of the Thaynes Formation.	23.9	23.9
	Total thickness of Nugget Sandstone	210.6 m	

Section 5

Section of Peterson Limestone measured along the west flank of the Miller Creek Syncline, NE ¼, section 15, T. 33 N, R. 119 W, Lincoln County, Wyoming.

		Thickness (meters)	
	Peterson Limestone	*Unit*	*Cumulative Section*
Unit			
11	Limestone: medium gray, weathers light yellow gray, medium bedded, shaly, some fossil fragments seen, forms a slope; contact with overlying Bechler Conglomerate located at disappearance of white limestone float.	8.2	62.4
10	Limestone: medium gray, weathers yellow gray, ledge former, thick bedded, well indurated, microcrystalline.	9.9	54.2
9	Limestone: swale former between more resistant ledge formers, shaly, fissile.	12	44.3
8	Limestone: thick to massively bedded, muddy, ledge former.	2.6	32.3
7	Limestone: similar to unit 9.	1.4	29.7
6	Limestone: medium gray, weathers light yellow gray, fossil fragments, medium to thick bedded, blocky, microcrystalline, abundant calcite stringers, ledge former.	2.4	28.3
5	Limestone: similar to unit 9.	10.7	25.9
4	Limestone: light gray, weathers medium light gray, thick bedded, blocky, microcrystalline.	5.2	15.2
3	Limestone: light gray, weathers olive gray, medium to thick bedded, shaly, no fossils seen, ledge former.	4.3	10
2	Limestone: similar to unit 4.	2.3	5.7
1	Limestone: similar to unit 3; contact with underlying Ephraim Conglomerate located at disappearance of light gray limestone.	3.4	3.4
	Total thickness of Peterson Limestone	62.4 m	

Section 6

Partial section of Twin Creek Limestone, Preuss Sandstone and Stump Sandstone, measured 0.8 km (0.5 mi) east of Stump Creek on the west flank of the Spring Creek Syncline, NW ¼, section 5, T. 7 S, R. 46 E, Caribou County, Idaho.

		Thickness (meters)	
	Stump Sandstone	*Unit*	*Cumulative Section*
Unit			
12	Covered: moderate brown soil; some sandstone float, pale red, medium grained, poorly sorted, calcareous, some noncalcareous; contact with overlying Ephraim Conglomerate covered, located at bottom of pale red soil.	57.6	646.8
11	Covered: greenish gray, weathers olive gray, abundant sandstone float, cross-bedded, ripple marked, medium grained, well sorted, abundant quartz, calcareous.	12.5	589.2
10	Sandstone: greenish gray, weathers olive gray, medium to thin bedded, abundant cross-bedding, ripple marked, cross-bed sets 1–3 cm, medium grained, well sorted, calcareous, ledge of cliff former.	4.6	576.7
9	Covered: similar to unit 11.	19.7	572.1
8	Sandstone: similar to unit 10; contact with underlying Preuss Sandstone located at appearance of red soil.	13.6	552.4
	Total thickness of Stump Sandstone	108 m	
Preuss Sandstone			
7	Covered: pale red sandy soil; abundant shale float, sandy, pale red, calcareous.	53.5	538.8
6	Sandstone: pale red purple, weathers to a grayish red purple, ledge former, thin to medium bedded, abundant ripple marks 1–5 mm high, locally calcareous.	58.4	485.3
5	Covered: poorly and rarely exposed, interbedded sandstone and shale; sandstone: pale red, thin bedded, fine grained, noncalcareous; siltstone: pale red, thin bedded, friable, noncalcareous; contact with underlying Twin Creek Limestone located at the appearance of splintery light gray limestone float.	215.7	426.9
	Total thickness of Preuss Sandstone	327.6 m	
Twin Creek Limestone			
4	Sandstone: pale olive, weathers brownish gray, thin bedded, some glauconite, poorly exposed, outcrops rare, calcareous, forms shoulder.	5.8	211.2
3	Covered: light pale red soil, occasional poor outcrops of limestone, thin bedded, splintery, shaly.	67	205.4
2	Covered: light pale red soil, abundant calcareous sandstone float, thinly bedded, medium grained, very similar to unit 5.	27.2	138.4
1	Covered slope: by splintery limestone, thinly bedded, shaly microcrystalline.	111.2	111.2
	Partial section of Twin Creek Limestone	211.2 m	

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