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TRIASSIC AND JURASSIC STRATIGRAPHY OF THE CAMP DAVIS AREA, WESTERN WYOMING

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SEDIMENTATION AND INTERFORMATIONAL RELATIONSHIPS

General discussion

Relationship of Permian to Triassic

Lower Triassic sedimentation

Middle or Upper Triassic sedimentation

Relationship of Triassic to Jurassic

Jurassic sedimentation

Jurassic--lower Cretaceous boundary

ABSTRACT

Triassic and Jurassic strata 2500 to 4000 feet thick are exposed in the vicinity of Camp Davis, Teton County, Wyoming, and they constitute a fairly complete series. The Triassic rocks of the eastern part of the Camp Davis area are closely related to the Dinwoody and Chugwater formations of the Wind River Basin, and those in the western part of the area are more closely allied to the Woodside, Thaynes and "Ankareh" formations of the geosyncline in Idaho. Of the Jurassic rocks the Nugget sandstone extends through and beyond the area with little variation. The Twin Creek, Preuss, and Stump formations are present, but only the upper half of the Twin Creek appears to exist in the Camp Davis area. The Morrison and the lower portion of the Cloverly appear to be equivalent to at least most of the Gannett group of Idaho. A mixture of lithologies of the eastern and western sections make up the Upper Jurassic and lowermost Cretaceous beds in the Camp Davis area.

INTRODUCTION

Location of area.--- The area studied is in northwestern Wyoming and includes parts of Teton, Sublette, and Lincoln Counties. Topographic maps of the U.S. Geological Survey thirty minute series cover the area on the Grand Teton, Mount Leidy, Gros Ventre, and Jackson quadrangles.

Nature of problem.--- The stratigraphic nomenclature of the Mesozoic rocks of the Camp Davis area was originally taken from previous work done to the west and southwest. The correlation was uncertain because few sections had been measured in detail near Camp Davis and because of the great disparity in thickness of the sections in southeastern Idaho and those of the Camp Davis region. The U.S. Geological Survey has recently made extensive investigations of the Mesozoic rocks of the Wind River Basin of central Wyoming east of the Camp Davis area. The charts indicate a need for reconsideration of the nomenclature in use at Camp Davis, because many similarities appear to exist between the rocks of the two areas.

There is, however, still a lack of detailed work to the west. Study is further complicated by the scarcity or lack of fossils in a large part of the section. Furthermore, reliable exposures are difficult to find in many places due to structural complications and dense forest cover.

While encouraging results were obtained from the first summer of study, another season in the field will be necessary before a really significant contribution may be made. Beyond that there will still remain sufficient material for several more advanced studies of a more detailed and limited nature.

Previous work.--- Geologic investigation in this area began with the Hayden Surveys. Orestes St. John (1883,p.188) measured a section of the Mesozoic rocks in the Wyoming range which included most of the strata here investigated. He placed no names on the beds and gave their ages only approximately. As quoted in Schultz (1914, pp. 55-56) the section contains few stated thicknesses and is at best highly generalized, and hence of little value in detailed work. Schultz used names used in southwestern Wyoming, but an element of uncertainty remains due to the lack of concrete evidence, paleontologically as well as lithologically. In 1938, however, Dobrovolny (1941) measured a detailed section near the St. John-Schultz locality and collected fossils which were later identified by Imlay. This section has been the basis for Camp Davis nomenclature for the Jurassic and Cretaceous, but it does not include the Triassic.

Fortunately, more extensive and detailed work has been done in adjacent areas. In 1907 Veatch published the results of his work in southwestern Wyoming and Boutwell published a professional paper on the Park City district of Utah. Subsequently their differences of nomenclature were resolved (Boutwell, 1912) and this terminology was used by Schultz (1914) in his report. The major stratigraphic units of the region were established by these reports.

In 1915 Mansfield published the first of a long series of reports on southeastern Idaho. These culminated in the bulletin on the Ft. Hall Indian Reservation (Mansfield, 1920) and the magnum opus, a professional paper covering seven quadrangles (Mansfield, 1927). The latter is not only one of the finest works on a region adjacent to the Camp Davis area, but also the most exhaustive and detailed available. While the measured sections are perhaps not quite detailed enough for further stratigraphic study, it is sufficiently clear to make tentative correlation possible even in view of the lack of fossil evidence in certain sections.

In central and eastern Wyoming considerable work has been done from the earliest days of exploration. (Blackwelder, 1918; Condit, 1918; Darton, 1899, 1908; Thomas, 1934; and others). The general picture has best been drawn in the Wind River Basin by the series of Preliminary Charts of the Fuels Division of the U.S. Geological Survey prepared by the Wyoming Project under the direction of J.D. Love (Love, et al, 1945, a,b,c). Many problems were solved by these charts, though some of the more controversial issues are still left unsettled. On the whole, however, their quality is such as to make an exhaustive review of the earlier literature unnedessary.

The work of Richmond in the Green River Lakes region is also available. (Richmond, 1945). His work, although primarily that of mapping the region and investigating the petroleum possibilities, included the measuring of a detailed section. It differs in many details from those published by the U.S. Geological Survey in the Wind River Basin, but may be correlated with them, and since it is the nearest detailed section to the Camp Davis Area, is helpful in bridging the gap.

Gardner (1944) in a report on the phosphate deposits of Teton Basin published a generalized section which included all the Mesozoic rocks in this region. This brings work from the west to within about twenty miles of the Camp Davis sections measured by the writer, and Richmond's section is only that far to the east.

There are three recent papers with a regional point of view on the Mesozoic of the Wyoming-Idaho-Utah region. Neely (1937) studied the Sundance and equivalents in Wyoming. Newell and Kummell (1942) concentrating on the Dinwoody, solved some of the problems presented by that formation by the application of paleontology. Imlay (1945) in the same manner shed some light on Jurassic correlation, revealing, in turn, more problems yet to be solved.

Literature is abundant on adjacent regions, but scarce on areas immediately surrounding Camp Davis. The problem, then, is to correlate Triassic and Jurassic sections of the Camp Davis area with those to the east as well as with those to the west, a problem complicated by the lack of good exposures in much of the Camp Davis area, and also by the disparity in the thicknesses, indicating that the region under study is critically situated on the edge of the great Triassic and Jurassic geosyncline.

Field work.--- Field work was carried on during parts of July and August, 1945, under direction of Dr. R.L. Belknap. Assistance was rendered by several of the Camp Davis students. The writer was assisted principally by Mr. William Yahn, but also by William Price, Warren Gilman, Miss Helen Abbott, Miss Gay Gilpin, Gerald Cooley, Eugene Chavez, John Horeth, and Hal Kaufman, at various times. The writer's wife, Alice, rendered considerable assistance both in the office and in the field. Miss Suzanne Takken also gave liberally of her time to assist with typing and preliminary plotting of the sections during the field season.

Weather was a great handicap during the 1945 field season. However, three sections each of Triassic and Jurassic rocks were measured. It was found practical to include the Lower Jurassic with the Triassic, and a part of the Lower Cretaceous with the nonmarine Jurassic. This division was maintained on the charts which make up plates 1, 2, 3, and 4.

TRIASSIC STRATIGRAPHY

General characteristics .--- In the Camp Davis region the Triassic consists largely of red siltstones and shales very similar in aspect to the Chugwater formation of central Wyoming. The lowermost part is limy, tan, and somewhat fossiliferous. In the upper portion several limestones appear which represent thicker limestones to the west. The entire section thickens westward to a total of about 6000 feet, but in the vicinity of Camp Davis its thickness is about 1500 feet.

<u>Measured sections</u>.--- The location and description of the Triassic and Lower Jurassic sections follow.

CHART I

Gros Ventre River Section. On north side of the Gros Ventre River valley about 3/4 mile northwest of the Lower Slide, on the Grand Teton Quadrangle. Secs. 5 and 6, T.42 N., R.114 W., and Sec. 32, T.43 N., R.114 W. (unsurveyed)

Gypsum Spring formation

Bed no.		Feet
40.	Limestone breccia, mostly gray, mottled with yellow and red.	2.
39.	Shale, red and yellow, covered.	5.

Nugget sandstone

38.	Sandstone, rusty-orange, cross-bedded in part, mostly fine, but some coarse sand up to 1/32 inch in diameter. Sand calcite balls 80 feet above base.	127.
37.	Sandstone, white to maroon, somewhat conglomerate with chert fragments up to 1/8 inch in diameter and some small calcite geodes. Poorly bedded.	6.
36.	Sandstone and siltstone, white, maroon, and rusty.	5.
35.	Sandstone, fine grained, white, ledge.	3.
34.	Shale, red, not well exposed.	.5
33.	Siltstone, fine grained, rusty, grains rounded and frosted, few rounded chert fragments about 1/16 inch in diameter. Poorly exposed.	3.5
	Total Nugget sandstone	145.0

Chugwater formation

Chugwater redbeds

32.	Siltstone, shaly, probably limy. Variegated with light maroon and green predominating, bedding irregular. Forms weak ledge.	2.5

31.	Shale, red, green, and heliotrope, and siltstone, orange. Light green at upper contact. Not well exposed.	8.
30.	Limestone, shaly, reddish, somewhat slabby, mottled on fresh surface, poorly exposed.	.7
29.	Shale, limy, and limy siltstone, weathers slabby.	.3
28.	Limestone, gray, weathers brownish, crinkled appearance, weathered surfaces rough. Many red and green fragments apparently of colored limestone included. Forms weak ledge. Alcova limestone member.	2.
27.	Siltstone and shale, red.	80.±
26.	Siltstone, light heliotrope to white, mottled, irregular bedding.	4.
25.	Shale, red, mostly covered.	8.
24.	Siltstone, limy, speckled with MnO_2, bedding uneven to cross-bedded.	5.
23.	Shale and siltstone, pink.	10.±
22.	Shale and siltstone, red.	100.±
21.	Limestone, lower part rather porous, upper part forms a slabby ledge.	7.
20.	Covered. Mostly red shale.	17.
19.	Limestone, forms slabby ledge, more porous and thicker bedded at top.	2.
18.	Covered. Probably about 2 feet of red shale, overlain by 4 feet of white, limy shale, and 4 feet of yellow-brown shale.	10.
17.	Limestone, porous, forms slabby ledge.	2.
16.	Siltstone, shale, and a small amount of sandstone; mostly brownish-red, some greenish-white to white. Colors other than red usually in the more porous beds.	180.±
15.	Limestone, white, porous, crystalline with chalky inclusions or pebbles.	.5
14.	Siltstone, red.	5.
13.	Limestone, white, porous, crystalline, with chalky angular fragments.	1.

12.	Siltstone, red, mostly covered.	3.
11.	Limestone, silty, white, somewhat banded; rather finely crystalline, with many calcite-filled cavities.	.5
10.	Siltstone, shale, a small amount of sandstone, mostly brownish-red, some greenish-white to white. Colors other than red usually in rocks which appear to be more porous.	590.
9.	Siltstone, slightly limy, slabby, brown, mostly covered.	33.
	Total Chugwater redbeds.	1071.5

Dinwoody member

8.	Siltstone, limy, tan to brown, irregularly bedded, containing poorly preserved fossils.	2.
7.	Siltstone, limy, brown, slabby, partly covered.	15.
6.	Limestone, argillaceous to arenaceous, thin cross bedding near base, thicker, irregularly bedding toward middle. Many calcite geodes. Forms conspicuous and rather persistant ledge. Top is very arenaceous.	32.
5.	Siltstone, limy, brown; thick, cross and irregular bedding. Forms several minor ledges.	17.
4.	Shale and siltstone, brown, mostly covered. Slightly more calcareous near top with more weak ledges showing than at bottom. *Lingula* present.	94.
3.	Siltstone, limy, makes rather prominent ledge. Gray, weathers brown and slabby. Contains *lingula.*	4.
2.	Siltstone, limy, gray, weathers brown.	2.
	Total Dinwoody	166.
	Total Chugwater	1237.5

Phosphoria formation

1.	Limestone, cherty, brown to black, not well exposed. Chert at top is chalky white.	5.

CHART II

Fall Creek Section: North bank of Fall Creek about one mile east of Wilson road bridge on Jackson Quadrangle. Sec. 20, T.39 N., R.116 W.

Gypsum Spring Formation

54.	Limestone, brecciated, gray, locally yellow stained.	20.±

Nugget sandstone

53.	Sandstone, quartzitic; orange to rusty near base, considerably lighter at 74 feet, nearly a tan color, and at top nearly white with pink staining; fairly fine grained throughout, grains mostly rather rounded and frosted.	350.±
	Total Nugget	350.±

Ankareh (?) formation

52.	Shale and siltstone, white.	1.
51.	Shale and siltstone, mostly lilac color.	1.
50.	Shale and siltstone, white to blue, thin-bedded.	1.
49.	Siltstone, shaly, massive and hackly to thin-bedded and slabby with a few calcareous layers and some thin gray limestones. Unit is mostly red and orange, with a few circular white spots up to an inch in diameter on the surface of the rock.	59.
48.	Siltstone, red, hackly, massive.	32.
47.	Siltstone, maroon with white specks, massive, weathers with a bluish cast.	25.
46.	Covered; probably red shale or siltstone.	42.
	Total Ankareh (?)	161.

Thaynes formation

45.	Limestone, gray, locally stained pink, massive weathers rough and blocky. Many small chert nodules throughout. Lenticular. (Alcova limestone ?)	5.
44.	Siltstone and shale, red, thin bedded and slabby to massive and hackly. Unit in general is similar to Woodside below but is much redder with less of the brownish cast of the Woodside.	220.
43.	Limestone, massive to thin bedded; thin bedded where shaly, gray, weathers buff, becomes pink in upper 5 feet.	45.±
42.	Siltstone, probably limy, thin bedded, reddish brown.	7.
41.	Limestone, massive to thin bedded; thin bedded where shaly, gray, weathers buff. Poorly preserved fossils which may be <u>Pleurophorus</u> about 46 feet from base. Forms prominent ridge.	158.
40.	Siltstone, limy, gray.	20.
39.	Limestone, gray, weathers tan.	4.
38.	Siltstone, white.	8.
37.	Limestone, gray, thin bedded, somewhat laminated and crinkled, mostly covered.	2.
36.	Siltstone, lower third brown, middle third reddish brown, upper third light tan. Some thin bedded limestone which is gray on fresh surface and weathers tan is found in upper third.	275.
35.	Limestone, in part shaly, gray, weathers tan to brown; upper ½ has a pinkish cast in streaks and weathers with a slightly pitted surface. Massive.	44.
34.	Limestone, light gray, weathers white, rather rough on weathered surface.	3.
33.	Covered.	5.
32.	Limestone, gray, weathers tan.	2.
31.	Siltstone, pink, thin bedded.	1.
30.	Limestone, gray, weathers tan.	2.

29. Covered. Appears to be porous limy siltstone, white to tan.	4.
28. Limestone, thick bedded, gray, weathers tan.	3.
27. Siltstone, bottom 1 foot white, upper 5 feet red. Poorly exposed.	6.
26. Limestone, gray, weathers tan, fairly thick bedded.	3.
25. Limestone, porous; conglomeratic, with many angular fragments of red siltstone up to an inch long. Not well exposed.	4.±
24. Shale, silty, red.	5.
23. Limestone, lower 3 feet pink and silty, upper 2 feet white.	5.
22. Siltstone, red, locally limy and more resistant, slabby, thin bedded.	4.
21. Limestone, shaly, gray on fresh surface, weathers tan; thin bedded and slabby to thick bedded and blocky.	6.
20. Limestone, porous, pinkish tan, weathered surfaces rough.	2.
19. Siltstone, shaly, limy, red.	1.
18. Limestone, porous, light pink, weathered surfaces rough.	2.
17. Limestone, thin shaly partings, thin bedded; tan below, grading to pink above.	3.
16. Shale, silty, light tan.	1.
15. Limestone, silty, light gray to tan, weathering darker tan, grades into overlying unit.	1.
14. Siltstone, red, white at top and bottom, grades into overlying unit.	1.
13. Limestone, silty, gray, weathers tan.	5.
12. Limestone, silty, thin bedded, pink to red, more silty at top, laminated and crinkled throughout. Grades into overlying unit.	6.
11. Siltstone; lower 6 feet red, middle foot white, upper 4 feet red; grades into overlying unit.	11.

10.	Limestone, silty, thin bedded, pink on fresh surface, light gray to tan when weathered.	4.
9.	Siltstone, limy, tan, thin bedded, partly covered.	58.
	Total Thaynes	936.

Woodside Shale

8.	Siltstone and shale, red, and minor amounts of sandstone, mostly white, partly covered.	300.
7.	Covered, probably red shale.	150.
6.	Siltstone, thin bedded, weak, tan.	5.
	Total Woodside redbeds	455.

Dinwoody member

Martin Creek Section: On north bank of Martin Creek a half mile above bridge on Bailey Creek Road, on Jackson Quadrangle. Secs. 8 and 9, T.38 N., R.116 W. (unsurveyed).

5.	Limestone, massive and blocky to arenaceous and thin bedded. Forms top resistant ridge of the Dinwoody. Contains well preserved _Lingula_. Upper 10 feet or so is irregularly bedded.	78.
4.	Siltstone, tan, mostly covered.	129.
3.	Limestone, arenaceous, thin bedded, slabby, upper part more resistant than lower.	30.
2.	Limestone, arenaceous, and siltstone; buff, mostly covered. Lower contact not certainly observed, but float fragment indicate possible thin flat pebble conglomerate near base.	45.
	Total Dinwoody	282.
	Total Woodside	737.

Phosphoria formation

1.	Limestone, cherty, light gray; lower part of unit more resistant, upper part exposed on back slope. Upper part more cherty and fossiliferous.	27.

CHART III

Dell Creek Section: On west bank of West Dell Creek, five miles above "Bellin's Ranch" on Gros Ventre Quadrangle. Sec. 20, T.39 N., R.112 W. (unsurveyed).

Gypsum Spring formation

Bed no.		Feet
40.	Limestone, conglomeratic with sandstone pebbles, cavernous.	5.

Nugget sandstone

39.	Sandstone, fine grained, mostly white, irregular to even, thin to massive bedding. Ripple marked at base; 2 inch calcite geodes at 80'; rounded sand calcite crystals at top. Top not well exposed.	325.
	Total Nugget	325.

Chugwater formation

Popo Agie member

38.	Sandstone, fine grained, with green siltstone pebbles at base. Thin green siltstone at top.	2.
37.	Siltstone, green.	.5
36.	Sandstone, silty, conglomeratic, with green siltstone pebbles in lenses.	2.
35.	Siltstone, green.	.5
34.	Siltstone, white, probably limy.	1.
33.	Siltstone, green.	.5
32.	Limestone, with green siltstone lenses irregularly throughout.	2.
31.	Siltstone, green.	4.
30.	Siltstone, probably limy, white. Green siltstone veins and some white chert.	1.5
29.	Siltstone, green.	.5
28.	Siltstone, white.	.5
27.	Siltstone, green and white.	1.

26.	Covered. Apparently green siltstone, soft.	12.
25.	Shale, green, hackly, soft.	30.
24.	Shale, red mottled with white, soft.	6.
23.	Siltstone, ochre, interbedded with lenses of white lime pebble conglomerate of from 3 inches to 1 foot thickness. Most of the pebbles are of the order of 1/8 inch in diameter, but red or orange shale or siltstone pebbles, usually larger and up to 20 millimeters occur.	9.
22.	Siltstone, ochre, bottom contact irregular.	20.
21.	Siltstone, conglomerate, with lime pebbles, white mottled with orange.	3.±
20.	Siltstone, limy, yellow, with a few shale pebbles. Unit is irregular and local, and apparently cuts into underlying unit.	2.±
	Total Popo Agie	98.

Chugwater redbeds

19.	Siltstone, shale, and minor amounts of sandstone, mostly red, some green. Ten feet from top is a 6 foot unit of limestone interbedded with red shale. The limestone is gray, arenaceous, and with crinkled bedding planes. (Alcova limestone).	252.
18.	Limestone, arenaceous, cavernous, with thin wavy bedding, white with maroon banding.	2.±
17.	Siltstone, shale, and minor amounts of sandstone, mostly red, some green.	76.
16.	Siltstone, white, contacts irregular.	4.
15.	Siltstone, red.	6.
14.	Siltstone, white, contacts irregular.	8.
13.	Siltstone, shale, and minor amounts of sandstone, mostly red, some green.	98.
12.	Limestone, arenaceous, cavernous, with thin, wavy bedding, white with maroon banding.	1.
11.	Siltstone, red, probably limy.	8.

10.	Limestone, arenaceous, cavernous, with thin wavy bedding, white with maroon banding.	6.
9.	Siltstone, shale, and minor amounts of sandstone. Mostly red, some green.	302.
8.	Sandstone, white, thin bedded.	7.
7.	Siltstone, shale, and minor amounts of sandstone. Mostly red, some green.	330.
6.	Covered, probably tan siltstone.	30.
	Total Chugwater redbeds	1130.

Dinwoody member

5.	Limestone, arenaceous, gray, weathers rusty. Lower contact irregular. Mostly massive, some layers argillaceous and thin bedded.	30.
4.	Siltstone, gray, weathers tan, with many small limy layers.	63.
3.	Limestone, and minor amounts of siltstone; gray, weathers rusty, with Lingula.	6.
	Total Dinwoody	99.
	Total Chugwater	1327.

Phosphoria formation

2.	Limestone, arenaceous cherty, white.	.5
1.	Limestone, arenaceous, cherty, gray to black.	30.±

Dinwoody and Woodside formations.--- The lower portion of the Triassic rocks consists of tan shales, siltstones, and limestones. These have been called the Dinwoody formation (Blackwelder, 1918). In this region the Dinwoody ranges from one hundred feet in thickness on Dell Creek to nearly three hundred feet on Fall Creek. In the past, many workers have drawn the upper contact at the top of the tan beds and the bottom of the red, but on this basis alone the contact may range vertically through a considerable thickness even ~~when~~ within a limited area. Newell and Kummel have properly drawn the contact on the basis of lithology "to include only dominantly silty strata between the Phosphoria and the top of the resistant siltstone." (Newell and Kummel, 1942, p. 941). The Dinwoody is predominantly a limy siltstone, and in this area is capped by a silty limestone which stands out as a prominent ledge. Below this ledge the siltstones carry abundant *Lingula*. Newell and Kummel have subdivided the Dinwoody on the basis of the fauna into a basal siltstone, present to the west of Camp Davis, a persistent *Lingula* zone, extending to the east of the Wind River mountains, and an upper *Claraia* zone, extending still further to the Owl Creek Mountains on the basis of their study. They postulate an overlap of the Dinwoody on the underlying Phosphoria not previously recognized.

The facies relationships of the Woodside and Dinwoody were suggested by Newell and Kummel. In Idaho the Woodside is largely tan siltstones and silty limestones of lithology similar to the Dinwoody, and the Thaynes contact is marked mainly by the prominent *Meekoceras* zone at the base of the

Ross Fork limestone. In the Fort Hall Indian Reservation the Woodside is similar but somewhat thinner.

The type Woodside of Park City, Utah (Boutwell, 1912, facing p. 46) is red shale. No Dinwoody or equivalent appears to exist there. Yet by stratigraphic position it seems clear that Boutwell's Woodside is equivalent to Mansfield's. On the basis of Veatch's section (1907, facing p. 50) which unfortunately is not detailed enough for accurate correlation, it would appear that the tan Woodside facies may be transgressive over the red facies in that area. This seems perhaps to be the most satisfactory way to explain the considerable simultaneous thickening of the Thaynes and thinning of the Woodside in the area covered by Veatch's report, with the total thickness of the Triassic remaining so constant.

Thaynes group and equivalents.--- Above the Dinwoody there are about a thousand feet of siltstones and shales, mostly red, with a few sandstones or limestones. Where the rock is permeable enough to allow the circulation of fluids the iron oxide which colors the formation is usually reduced to a yellow or green, or even leached white. In this entire section the limestones have proved the only reliable horizon markers. On the Gros Ventre and Dell Creek sections three limestones or limy zones are found, which may be correlated on the basis of constant stratigraphic intervals and lithologic similarity. The Fall Creek section is somewhat thicker and contains more limestone, but a satisfactory correlation may be effected there also on the same basis. In the lower portion of the section there appears a third limy zone, and the section is thicker. No corresponding unconformity is recognized in the Gros Ventre and Dell Creek sections, and the limestone in question is interbedded with red shales and siltstones similar to those both above and below. The simplest explanation seems to be the "feathering out" of the limestone by intricately interfingering with the shales and siltstones to the east. The two lower limestones of the eastern localities seem to be the uppermost and lowermost portions of the second limestone on Fall Creek. (Plates 1 & 2). Their peculiar porous and conglomeratic characteristics would seem to indicate formation in shallow water, if not near shore. (Charts I & III, pp. 10,17, & 18). The upper limestone of all three localities is by far the most interesting and important, however, since by both stratigraphic position and lithology this appears to be the Alcova limestone which provides in regions to the east the only marker bed in approximately 1000 feet of redbeds of the Chugwater formation. Lithologically it is rather distinct; usually it is gray, though sometimes pinkish, crystalline, with thin crinkled bedding. It is weather resistant and usually makes a prominent ledge where present, though seldom over ten feet thick. (Charts I, II, & III, pp. 10, 12, & 17).

In the Green River Lakes section Richmond correlated the lower of the two limestones with the Alcova. However, in view of the correlation shown in Plate 1, and because the interval from the bottom of the Chugwater to the Alcova limestone is ordinarily more constant and reliable than from the top, it appears more reasonable to correlate the upper one with the Alcova. Unfortunately the writer was unable to examine the Green River Lakes section and it is quite possible that Richmond's is the correct interpretation. The Alcova has been called Middle or Upper Triassic by some, but it seems more likely to be Lower Triassic. (Newell & Kummel, 1942, p. 949).

The lowest limestone on the Fall Creek section is probably equivalent to Mansfield's Ross Fork limestone, the lowest member of the Thaynes group. On Fall Creek it is largely a gray silty to shaly limestone, weathering tan, and interbedded with red siltstones. Some beds are rather porous and contain reworked limestone pebbles (Chart II, p~~p~~. ~~13-~~14), their aspect generally being similar to beds described on the Gros Ventre River somewhat higher in the section. Here again a shallow water, if not near shore, environment is suggested. In southeastern Idaho the Ross Fork is made up of tan to brown sandstones, limy sandstones, and sandy limestones, and the lower contact is marked by a zone containing _Meekoceras_ and other ammonites. No fossils were found in this limestone on Fall Creek. Correlation is on the basis of stratigraphic position and lithologic similarity.

Above the Ross Fork limestone in Idaho is a series of gray and olive colored calcareous shales and sandstones. A few fossils are found. On Fall Creek what may be the equivalent unit is a light tan to reddish brown to brown, locally limy siltstone, but no fossils were found in it.

The Portneuf limestone on the Fort Hall Indian Reservation is apparently entirely limestone. In the Freedom and Henry quadrangles, however, it is split into a lower limestone, a middle redbeds member, and an upper limestone. The formation has a characteristic fauna which is found in both limestone members. On Fall Creek a few small fossils were found in lower limestone which may have been _Pleurophorus_ but these were poorly preserved and their identity uncertain at best. Furthermore _Pleurophorus_ is primarily a Carboniferous form which continued into the Woodside of Idaho but is not known in the Thaynes. (Mansfield, 1927, p. 94). It may be that non-contemporaneous faunal equivalents may exist here which only further research will reveal.

The redbeds member appears to thicken from Freedom quadrangle, Idaho, southward at the expense of the upper limestone member. At Indian Creek, near Hot Springs in Bear Lake County, Idaho, the upper limestone is about thirty feet thick, and the redbeds are approximately 600 feet thick. (Mansfield, 1927).

It appears that they exhibit a similar relationship when traced to the northeast. The upper limestone member on Fall Creek is only a few feet thick, but it is this limestone that probably correlates with the Alcova of central Wyoming, thus carrying the upper Thaynes contact far to the east, although the lower Thaynes contact is indistinguishable to the east of the Fall Creek section.

Middle or Upper Triassic formations.--- On Dell Creek about 100 feet of orange and green siltstones and shales with interbedded lime pellet conglomerates represents the Popo Agie (pronounced pŏpŏ́ zhă) member of the Chugwater in the Wind River Basin. It is possible that beds to the west are of equivalent age, Middle or Upper Triassic. To the east the Popo Agie is known to interfinger with redbeds, (Love, et al, 1945c), and probably merges into a part of the Chugwater formation. Some such relationship may exist to the west also. Further studies are necessary to determine the exact relationships, but it will be difficult due to the lack of exposures and scarcity of fossils.

Above the Thaynes in Mansfield's sections are a few hundred feet of shales, sandstones, and limestone, part of which were originally called Ankareh and the remainder members of the Nugget formation. In later work Mansfield raised them into four separate formations, recognizing that the Higham grit, Deadman limestone, and Wood shale were probably equivalent in some manner to part of the Ankareh of Boutwell. In the same manner they are probably equivalent to the portion of the Triassic above the limestones in the Camp Davis region. The Timothy sandstone, which lies below the Higham grit and above the Thaynes group, is probably unconformable on the Thaynes, and the Higham rests perhaps unconformably on it. The existence of these unconformities in the Camp Davis region were not observed, and it may be that the Timothy also is represented as part of the section above the Alcova limestone.

Problems of nomenclature.--- The final problem is the placing of names upon the various units. Newell and Kummel have used the names Woodside and Thaynes from the southwest, but point out that the names hould not be used where not easily applied. Woodside-Thaynes has been applied in the Camp Davis area formerly, but there is in the literature no justification of the hyphenation. Such a name begs the question and is cumbersome and nearly meaningless. The name Chugwater has long been in use in the Wind River Basin and is well established as a useful term there. It is here proposed to extend its usage to the approximate vicinity of Fall Creek, or wherever the Woodside and the Thaynes become distinguishable. From there westward, Woodside and Thaynes should be used. When the relationships of the overlying Triassic formations are more clearly understood, it may prove of value to extend Chugwater westward as a series name.

The Dinwoody also presents a problem in nomenclature. To the west Dinwoody-like rocks apparently expand to make up what has been called Woodside, and far to the east the Dinwoody feathers out into red shales of the Chugwater formation. (Thomas, 1934, p. 1697). It would seem best, therefore, to reduce the Dinwoody to a member of the Chugwater or Woodside, where each name is applicable, and recognize it only in regions where it can be clearly identified.

Also shown on Plate 1 are Mathews' (1931, p. 387) subdivision of the Thaynes into the Emigration and Pinecrest formations. The lower is probably approximately equivalent to the Ross Fork limestone and the Fort Hall formation and the upper to the Portneuf limestone. The limestone apparently placed at the top of the Thaynes by Mathews was originally placed in the Ankareh by Boutwell (Plate 1). The fauna it contains, however, is identical to that of the Thaynes and it appears that the contact should be placed as shown on the right hand side of the Park City column. (Plate 1).

TRIASSIC AND LOWER JURASSIC SECTIONS

PLATE I

PARK CITY, UTAH TO HORSE CREEK, WYO.

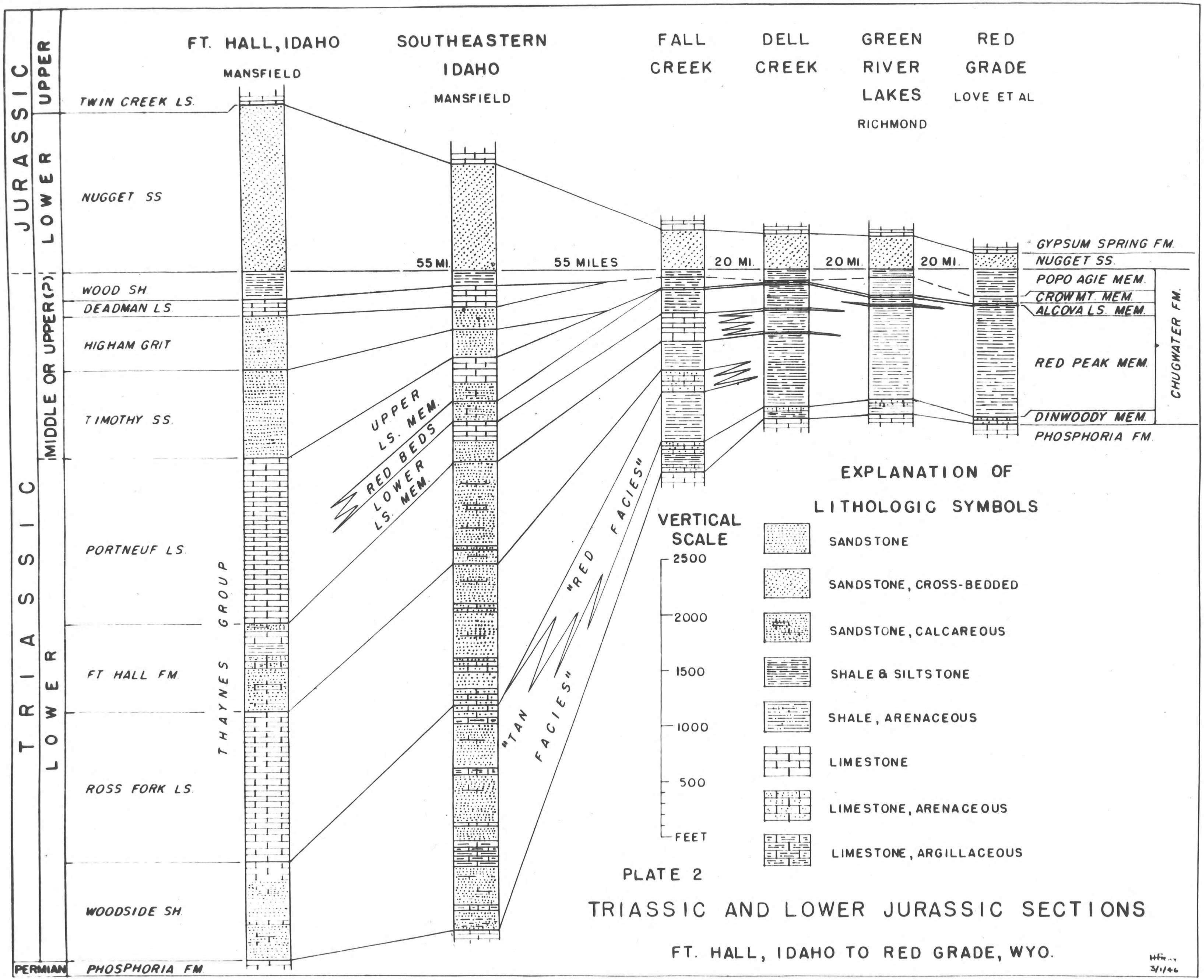


PLATE 2

TRIASSIC AND LOWER JURASSIC SECTIONS

FT. HALL, IDAHO TO RED GRADE, WYO.

JURASSIC STRATIGRAPHY

General characteristics.--- The Jurassic of the Camp Davis area may be divided into three general units for the convenient study, each of which thickens southwestward. The Lower Jurassic consists of one unit, the Nugget sandstone. It was found convenient in the field to measure the Nugget along with the Triassic, and it is also included with the Triassic on plates 1 and 2, though discussed separately. It ranges from less than 100 to over 300 feet thick in the Camp Davis area. The marine Jurassic presents a convenient unit for study and is illustrated on plate 3. It consists of shales, sandstones, and limestones, which are mostly gray to gray green in color. Its total thickness is from 600 to 800 feet. The non-marine Upper Jurassic is not generally distinguishable from the non-marine Lower Cretaceous, and they are therefore discussed together and shown on plate 4. They consist of light colored massive sandstones and dark to light variegated shales with some limestones. Their total thickness ranges from about 400 to 700 feet.

<u>Measured sections</u>.--- The Gros Ventre River and Hoback River Canyon sections were partially adapted from sections previously measured by Camp Davis faculty and students.

CHART IV

Gros Ventre River Section: One half mile east of IWW Creek, on north side of the Gros Ventre river, opposite the lower slide, on Grand Teton Quadrangle. Section 5, T.42 N., R.114 W. (unsurveyed)

Gypsum Spring formation

Bed no.		Feet
12.	Shale, red.	10.±
11.	Limestone, brecciated, gray.	15.±
10.	Sandstone, yellow, fine grained, weak, in irregular lenses.	.5±
9.	Limestone, brecciated, mostly gray but mottled with yellow and red. Many fragments are sub-angular and it locally appears to be almost a conglomerate rather than a breccia.	6.

Nugget sandstone

8.	Sandstone, rusty, cliff forming.	85.
7.	Covered, probably white sandstone.	1.
6.	Limestone, silty, pink and white.	6.
5.	Covered, probably pink and white sandstone.	2.
4.	Limestone, crystalline, white, speckled.	5.
3.	Covered, probably red shale or sandstone.	3.
2.	Limestone, crystalline, white, speckled.	1.
	Total Nugget	103.

Chugwater formation

1.	Siltstone, partly limy,maroon and green mottled.	3.

CHART V.

Gros Ventre River Section; One to two miles above Lower Slide on north side of Lower Slide Lake, on Grand Teton Quadrangle. Sec. 4, T.42 N., R.114 W. (unsurveyed).

"The Rusty beds"

Bed no.		Feet
54.	Sandstone and shale, gray to buff to black.	52.
53.	Sandstone, brown to buff, massive.	15.

Gannett group

Cloverly (restricted) formation

52.	Covered.	57.
51.	Mudstone, red and light gray.	24.
50.	Limestone, gray, with many small limestone pebbles.	.5
49.	Limestone, finely crystalline to lithographic, gray.	9.5
48.	Limestone, argillaceous, lithographic, light gray.	9.5
47.	Mudstone, red to lilac and green, with some botryoidal chalcedony.	81.
46.	Mudstone, red, occasional so called "gastroliths"	29.5
45.	Sandstone, gray, coarse grained, thin bedded, friable. Weathers buff to gray.	4.
44.	Sandstone, yellowish brown, coarse grained, lower part thicker bedded than upper, several beds reddish in color and better cemented than rest of unit. Contains a few chert pebbles up to 1/4 inch in diameter and considerable secondary quartz.	16.
43.	Sandstone, buff to gray, mostly covered.	6.
	Total Cloverly (restricted)	237.

Morrison (?) formation

42.	Shale, black, hard, weathers red.	4.
41.	Covered.	21.

40.	Sandstone, massive, medium grained, cross bedded and poorly cemented, weathers buff.	23.
39.	Covered.	36.
38.	Sandstone, shaly, greenish, chloritic. Bottom 10 feet mostly covered but a few limy ledges are seen. Partly massive, partly thin bedded.	28.
37.	Sandstone, shaly, greenish, considerable chlorite. Contains angular fragments of green shale. Massive.	13.
36.	Sandstone, shaly, green, chloritic.	3.±
35.	Shale, silty, red.	7.±
34.	Sandstone, shaly, green.	5.
33.	Sandstone, limy, and sandy limestone, white, weathers buff.	2.
32.	Shale, red.	5.5
31.	Shale, silty, green.	5.5
30.	Sandstone, silty, limy, brownish on surface, bedding thin to medium.	2.
29.	Shale, lower 10 feet red, upper foot green. Black limestone nodules at bottom.	11.
28.	Sandstone, limy in bottom part, lower contact irregular, contains many pieces of green shale in angular fragments up to 2 inches long but mostly about $\frac{1}{2}$ inch long in many small irregular lenses.	17.
27.	Sandstone, shaly, green, soft, chloritic.	3.
26.	Shale and siltstone, red, locally green, locally a shaly limestone.	5.
25.	Sandstone, shaly, green, with some glauconite.	2.5
24.	Shale and siltstone, red and orange.	1.5
	Total Morrison (?)	195.
	Total Gannett group.	432.

Stump sandstone

23.	Sandstone, greenish, weathering buff, lower 15 feet slabby, upper part more massive, weathering rounded, lower part glauconitic, upper part less so but containing many brown rusty grains. Unit forms a conspicuous cliff.	46.
22.	Sandstone, greenish, soft, glauconitic, slabby.	4.
21.	Sandstone, limy, green, weathers slabby and forms a rather prominent ledge.	12.
20.	Sandstone, shaly, green, highly glauconitic, mostly covered.	15.
19.	Limestone, sandy, finely conglomeratic, weathers slightly slabby. Glauconite abundant. A few small Rhynconellids present.	2.
18.	Shale, sandy, green, glauconitic, mostly covered.	55.
	Total Stump.	134.

"Lower Sundance"

17.	Siltstone, soft, red, mostly covered.	15.±
16.	Shale and shaly sandstone, gray, soft, mostly covered.	46.±
15.	Shale, greenish gray, soft, contains abundant *Gryphaea.*	178.
14.	Limestone, oolitic, gray, massive, with some fossils.	5.
13.	Shale, gray, soft, mostly covered.	37.
12.	Limestone, oolitic, gray fossiliferous.	21.
11.	Shale, greenish gray and red, soft, mostly covered.	95.
10.	Shale, dark gray, weathers into angular fragments.	15.
9.	Limestone, bluish gray, weathers buff.	1.
8.	Shale, calcareous, dark gray, weathers lighter, hackly, contains numerous fossils. *Pholadomya*, *Pleuromya*, *Astarte*, *Trigonia*, etc.	9.
7.	Limestone, oolitic, finely crystalline, thin bedded, dark gray, weathers lighter.	16.
	Total "Lower Sundance"	438.

Gypsum Spring formation

6.	Shale, gray, calcareous, soft.	3.
5.	Shale, red, soft.	15.
4.	Limestone, brecciated, crystalline, massive, upper part more finely crystalline, lower part somewhat arenaceous.	28.
3.	Shale, grayish green and red, lower part red and arenaceous.	5.±
	Total Gypsum Spring	51.

Nugget sandstone

2.	Sandstone, pink and white, cross bedded.	4.
1.	Sandstone, rust to salmon color, medium grained friable, thick bedded to massive.	38.

CHART VI

Fall Creek Section; north side of Fall Creek $1\frac{1}{2}$ to 2 miles east of bridge on Wilson road, on Jackson Quadrangle. Secs. 21 and 28, T.39 N., R.116 W. (unsurveyed).

Bear River formation

Bed no.		Feet
71.	Shale, silty, gray, thin to medium bedded, weathers gray to tan to rusty, slabby to blocky fracture.	4.

Gannett group

Bed no.		Feet
70.	Siltstone, maroon to red, locally weathers rusty. Fracture hackly to blocky. Massive.	6.
69.	Covered. A mile and a half south, on the north bank of the Snake river, this unit appears to consist of, from top to bottom: 7. Shale, light gray. 80. 6. Limestone, gray, weathers tan. 10. 5. Shale, light gray. 60. 4. Limestone, gray, weathers tan. 5. 3. Shale, light gray. 25. 2. Limestone, gray, weathers tan. 5. 1. Shale, mostly light lavender. 65. (These subdivisions estimated)	250.
68.	Limestone, shaly to silty, conglomeratic, gray, weathers white to gray. Pebbles are white rounded limestone fragments up to 2 inches.	20.
67.	Limestone, lithographic, gray, weathers tan, massive.	2.
66.	Limestone, lithographic, gray, weathers lighter, massive.	5.
65.	Limestone, lithographic, gray, weathers tan, massive, with sub-conchoidal fracture. Local thin shaly seams and pebbles near bottom.	9.
64.	Limestone, lithographic, gray, massive, weathers darker gray. Becomes more shaly toward base and fracture changed from blocky to hackly.	18.
63.	Shale, reddish maroon, hackly.	11.
62.	Limestone, arenaceous, gray, becoming conglomeratic in lower foot or so with sub-angular pebbles up to $\frac{3}{4}$ inch in diameter.	4.

61.	Covered. Probably red shale.	60.
60.	Limestone, gray, lithographic, reddish on weathering, blocky to hackly.	6.
59.	Covered, probably red shale.	50.
58.	Sandstone, caleareous, banded pink and white, somewhat cross bedded.	20.
57.	Siltstone, red, hackly, soft.	1.
56.	Sandstone, pink to white, calcareous. Half foot of conglomerate at base.	4.
55.	Sandstone, calcareous, pink to white. Lower contact quite irregular.	1.
54.	Sandstone, calcareous, pink to white, conglomeratic at base with flat red shale or siltstone pebbles up to an inch long. Sand is rounded and sorted, polished and rather fine grained.	1.
53.	Siltstone, pink, hackly, soft.	3.
52.	Limestone, arenaceous at top, grading into a limy sandstone below, with bottom 3 feet or so conglomeratic with rounded chert pebbles up to half an inch, in diameter and also some pebbles of sandstone, limestone, and shale. Mostly gray, weathers tan to pink. (Base of Cloverly formation?)	16.
51.	Limestone, silty, fine grained, massive. Bottom more silty and irregularly thin bedded.	3.
50.	Sandstone, calcareous, white, thick to thin bedded, coarse grained, with many pink grains. Bottom contact not well exposed.	13.
49.	Covered.	65.
48.	Sandstone, locally calcareous, thin bedded at top to thick bedded below, white, coarse even grained.	16.
47.	Covered.	12.
46.	Sandstone, coarse, even grained, white, weathers tan, green shale fragments in base.	2.
45.	Covered.	2.
44.	Sandstone, shaly, green, chloritic, thin bedded.	2.
43.	Sandstone, white, with green shale fragments.	3.

42.	Sandstone, white in upper half, gray, weathering rusty in lower half, coarse grained. Lower portions very conglomeratic with shale and fossil wood fragments. Mostly thin bedded, weathering rounded to slabby.	30.
41.	Covered. Probably greenish silty shale.	3.
40.	Sandstone, white, few pink grains and many dark minerals, thin bedded and slabby to thick bedded and rounded, coarse grained.	18.
39.	Covered. Probably red shale.	30.
	Total Gannett	686.

Stump sandstone

38.	Sandstone, finegrained, calcareous, glauconitic, green, weathers greenish to reddish brown.	24.
37.	Sandstone, fine grained, calcareous, and limestone, arenaceous. Sandstone, is sparsely glauconitic. Limestone more predominant toward base. Few fossils, poorly preserved, near base.	40.
36.	Limestone, arenaceous, gray to gray green, weathers tan to white, slabby to blocky, thin to unevenly bedded. Glauconite sparsely in some beds.	32.
	Total Stump	96.

Preuss sandstone

Fall Creek Section: one half mile up gully on north side of Fall Creek, one half mile east of bridge on Wilson road, on Jackson Quadrangle. Sec. 20, T.39 N., R.116 W. (Unsurveyed).

35.	Shale and siltstone, red and green. Top 3 feet or so is green.	44.
34.	Siltstone, red.	1.
33.	Shale, locally silty, red and green, hackly, weathers rounded.	10.
32.	Sandstone, white, weathers pink, containing many fragments of red and greenish shale in irregular lenses.	6.
31.	Siltstone and shale, red to brown, poorly exposed.	14.
30.	Sandstone, white, weathers gray and rounded.	4.5

29.	Siltstone, somewhat sandy, red, cross bedded, fracture hackly, contact with underlying limestone somewhat uneven.	45.
	Total Preuss	124.5

"Lower Sundance"

28.	Limestone, oolitic, dark gray, weathers rusty to greenish, numerous calcite veins, massive near top but with many shaly partings and pebbles in lower 6 feet. Much jointed. Forms conspicuous cliff.	42.
27.	Shale and limy shale with some thin limestones, brown, mostly covered.	5.5
26.	Limestone, oolitic, black, with several shaly partings about 6 inches thick. Pebbles of shale and many calcite veins and stringers occur in the limestone beds.	9.
25.	Shale, mostly covered.	2.5
24.	Limestone, oolitic, black, with some shaly elongated nodules and partings. Oölites are pinkish and somewhat transparent.	1.
23.	Shale, soft, brown.	1.
22.	Limestone, oolitic, crystalline, black weathers gray.	4.5
21.	Shale, limy, with splintery fracture, with abundant _Gryphaea nebraskensis_ near base.	220.
20.	Limestone, brownish gray, fossiliferous.	1.
19.	Shale, limy with splintery fracture.	42.
18.	Limestone, shaly, interbedded with shale, brownish gray, splintery fracture. Numerous fossils, mostly _Gryphaea._	3.
17.	Shale, limy gray, splintery.	16.
16.	Limestone, shaly, gray, with fossils.	5.
15.	Shale, limy, and shaly limestone, gray, with splintery fracture. _Camponectes_ and _Pinna_ from about 22 feet above base.	87.
14.	Limestone, shaly, gray, splintery fracture.	34.

13.	Limestone, gray, oolitic.	3.
	Total "Lower Sundance"	476.5

Gypsum Spring formation

12.	Limestone, shaly, gray, thick to thin bedded, splintery fracture, fossil fragments at 12 feet above base.	28.
11.	Shale, greenish gray, soft.	1.
10.	Shale, silty, brecciated, red.	30.
9.	Covered. Appears to be greenish gray shale.	33.
8.	Limestone, shaly, and limy shale, mostly covered. Shell fragments, probably _Pholadomya_ and a _Trigonia_ from about 8 feet above base. _Astarte_ from about 15 feet.	22.
7.	Shale, calcareous, hard, gray, splintery, forms a few small ledges.	22.
6.	Shale, soft, greenish gray.	18.
5.	Limestone, brecciated, gray.	1.
4.	Shale, soft, greenish gray.	5.
3.	Limestone, brecciated, gray with calcite veins.	3.
2.	Mostly covered. Underlain at least in part by reddish to greenish clays and shales with a limy conglomerate at base containing reworked pebbles of Nugget sandstone and some limestone pebbles.	7.5
	Total Gypsum Spring	170.5

Nugget sandstone

1.	Sandstone, white to light buff.	22.

CHART VII

Hoback River Section: Three quarters to one and a half miles west of mouth of Granite Creek on north bank of the Hoback River, on Jackson Quadrangle. Secs. 5 and 6, T.38 N., R.114 W. (unsurveyed).

Gannett Group

Bed no.		Feet
23.	Siltstone, sandy, red irregularly bedded.	3.
22.	Shale, red, soft, hackly.	24.

Stump sandstone

Bed no.		Feet
21.	Sandstone, greenish gray, thin even bedded, some layers calcareous. Upper 5 feet or so is massive and weathers rounded and contains many calcite veinlets and weathers reddish. Entire unit is glauconitic.	36.
20.	Sandstone, greenish gray, glauconitic, thin bedded.	11.
19.	Limestone, arenaceous, greenish gray, glauconitic, weathers buff. Contains <u>Belemnites</u>.	9.
18.	Limestone, arenaceous, greenish gray, with some layers of greenish gray sandstone. Some lenses are coarsely crystalline and contain a few pebbles up to 1/8 inch in diameter and frequently a large number of <u>Pentacrinus</u> columnals on the bedding planes. Abundant glauconite.	<u>33.</u>
	Total Stump	89.

Preuss sandstone

Bed no.		Feet
17.	Siltstone, red, massive, and hackly in lower part, thin, even bedded in upper part, with fine shaly partings and a few small ripple marks on some bedding planes.	20.
16.	Siltstone, white, thin bedded, locally cross bedded, with a few small ripple marks.	6.

15.	Siltstone, red to pink, locally mottled to white, thick bedded to massive and hackly in lower 3/4, thin bedded in upper 1/4. Locally calcareous and more resistant.	28.
	Total Preuss	54.

"Lower Sundance" formation

14.	Limestone, oolitic, slightly arenaceous, ripple marked, greenish to reddish gray, weathers rusty. Thick bedded, forms prominent ridge. Locally the fresh color is pinkish and the oolites are pink and semi-transparent.	28.
13.	Shale, dark gray, soft, with numerous specimens of Gryphaea nebraskensis.	290.
12.	Limestone, dark gray, lithographic, numerous calcite veins, massive in lower part, thick bedded in upper.	27.
11.	Limestone, argillaceous, and a few thin beds of shale, with angular fracture.	31.
10.	Shale, gray, calcareous, mostly covered.	13.
9.	Shale, red, soft, mostly covered.	22.
8.	Limestone, argillaceous toward base, finely crystalline and lithographic toward top, dark gray, thin bedded, with angular fracture. Contains Camptonectes and applicated Ostrea.	18.
7.	Shale, calcareous, gray, largely covered. Fracture splintery. Contains Pentacrinus and Camptonectes.	118.
6.	Limestone, oolitic, dark gray, thick bedded.	46.
5.	Shale, calcareous, dark gray, with splintery fracture. Contains some pelecypods.	2.5
4.	Limestone, oolitic, thick bedded, dark gray.	16.
	Total "Lower Sundance"	611.5

Gypsum Spring Formation

3.	Shale, red in lower part, gray in upper part, mostly covered.	33.

2.	Limestone, brecciated, massive. Lower foot locally contains angular fragments of sandstone and soft red shale. Lower contact appears to be somewhat irregular but is not well exposed.	50.
	Total Gypsum Spring	83.

Nugget sandstone

1.	Sandstone, reddish brown, base not exposed.	100.

The Nugget sandstone.--- The Nugget sandstone is found throughout the area studied and extends to the north and east for a considerable distance. Its thickness ranges from about 1500 feet in central Idaho, uniformly decreasing to thirty feet on Horse Creek, near Dubois, Wyoming, and it wedges out completely on the flanks of the Owl Creek mountains. The Nugget is almost entirely sandstone; locally it contains sand calcite crystals of a peculiar, nearly spherical shape and geodes up to two inches in diameter in zones which appear to have no value in correlation. The sand grains are usually frosted. Locally also there are zones which contain abundant frosted shperes of quartz about one millimeter in diameter. Usually the formation is rather friable and is not highly resistant to weathering. In many places, however, it is quartzitic and is a good ridge former. This quartzitic tendency appears to increase near the major thrust faults, but only where the sandstone is fairly thick. In color it is rusty, pink, salmon, or white. Throughout the entire section there appears to be no reliable marker horizon, but the unit as a whole is so distinct as to make correlation rather obvious. The sandstone is prominently cross-bedded, though the exact nature or origin of the cross bedding is not certain. It is thought that the Nugget is a dune sand reworked from time to time in playa lakes which covered local areas and from which perhaps came the calcite found in many localities. There are limestones at various horizons in the Nugget, but no fossils have been reported except a few obscure footprints described by Mansfield (1926, p. 97) and a doubtful Trigonia.

The Nugget rests unconformably on the underlying Lower or Middle Triassic formations and is overlain unconformably by the marine Middle Jurassic. It is thought to be of Lower Jurassic age. (Mansfield, 1927, p. 97). For some time the lower unconformity was suspected but no conclusive evidence was found. In the latter portion of this paper, evidence in support of this view will be presented.

<u>The Marine Jurassic formations</u>.--- The Marine Jurassic (Plate 3) in the Camp Davis Region presents fewer difficulties than the Triassic. This is due not only to the fact that the section is fossiliferous and has been the subject of considerable study, but also to the fact that the problem is less complex and facies changes are not so abrupt.

The Twin Creek and Stump formations in the Camp Davis region have long been recognized as the approximate equivalents of the Sundance formation of eastern Wyoming. This long-range correlation was made on the basis of the fauna. Later work has shown no reason to doubt the relationship. (Neely, 1937, p. 754). Recent charts of the U.S. Geological Survey follow Neely in the use of the terms "Upper Sundance" and "Lower Sundance". In the Wind River Basin the Gypsum Spring formation is recognized below the "Lower Sundance". (Love, et al, 1945b).

The Gypsum Spring formation (Love, 1939. p.45; Love, et al, 1945b) consists in the Wind River Basin of limestones, dolomites, red shales, and large quantities of gypsum. Where the gypsum is absent the limestone is commonly brecciated and the formation is thinner. In the Camp area no gypsum occurs in this formation. Basal conglomerates are rare in the Wind River Basin, but in the Camp Davis region the basal breccia commonly contains material in the lower few feet which appears to have been derived from the underlying Nugget sandstone. In the Gros Ventre River section there is some evidence of channeling of the Nugget. (Tables IV & V). With these exceptions the Gypsum Spring formation maintains its lithologic character through the Camp Davis region, but its relation to the Twin Creek of Southeastern Idaho is not well known. It is apparently Bathonian (Upper middle Jurassic) to Callovian (Upper Jurassic) in age. The lower portion of the Twin Creek, however, is of the somewhat older Bajocian (Lower middle Jurassic) stage. (Imlay, 1945). The large fauna reported from the Gypsum Spring (Love, et al, 1945b) is largely new and undescribed, and as such is of little help in the present problem. Undescribed species of <u>Pholodomya</u>, <u>Trigonia</u>, and <u>Astarte</u> were found in this formation on Fall Creek by Ehlers and identified by Kellum (personal communication).

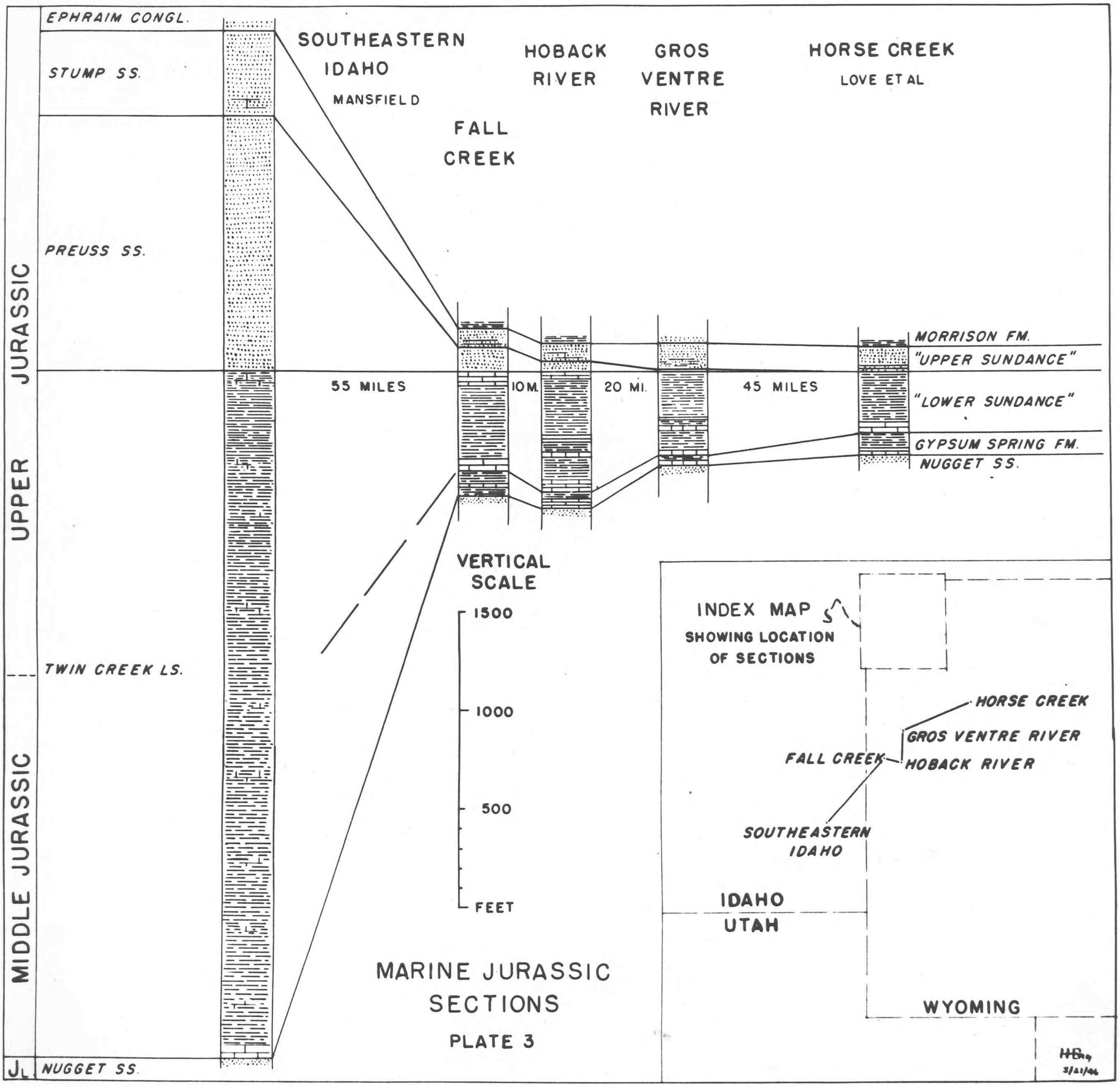
Above the Gypsum Spring is a sequence of fossiliferous gray shales and shaly limestones. The limestones are commonly oolitic, and the lowest oolitic limestone is taken to mark the base of the unit which is at present called "Lower Sundance" by the U.S. Geological Survey. The unit is lithologically similar to the Twin Creek of Idaho, but faunally is apparently equivalent to only the upper part of that formation. (Imlay, 1945).

Near the top of the formation a thick gray limy shale occurs in which are found abundant specimens of <u>Gryphaea nebraskensis.</u> This zone is remarkably persistant in the Wind River Basin and the Camp Davis Area and forms a valuable and easily found marker in the Marine Jurassic. <u>Gryphaea</u> are found elsewhere in the Jurassic section but nowhere in such abundance.

Above the Twin Creek in Idaho is 1,300 feet of red, fine-grained, calcareous sandstone of the Preuss formation. This unit thins rapidly northeastward. On the Hoback River it is represented by 52 feet of red and white limy siltstones, and on the Gros Ventre River it is not clearly recognized though it is perhaps present. It may be that the "Sundance Red Zone" at the top of the "Lower Sundance" in part of the Wind River Basin (Love, et al. 1945b) represents the Preuss. No fossils have been found, but since the underlying and overlying rocks are of upper Jurassic age, the Preuss is necessarily of that age. Imlay (1945, p. 1020) places the Preuss in the Callovian stage, and relates it more closely to the Twin Creek than to the Stump. Mansfield (1927,p.99), on the other hand, states that the Preuss rests unconformably on the Twin Creek and grades upward into the Stump, relating it thus more closely to the overlying formation.

Above the Preuss in the Camp Davis area and above "Lower Sundance" in the Wind River Basin is a sequence of sandstone and limy sandstone. They are characteristically thin bedded and slabby, gray-green in color, and on the weathered surface, slightly rusty. The limy sandstones occur for the most part near the base of the formation and are fossiliferous and conglomeratic. The fossils include a Rhynconellid c.f. Kallirhyncia myrina and a Beleminite probably Pachyteuthis densus in the Wind River Basin and Camp Davis area. The greater part of the formation is glauconitic and the presence of this mineral usually marks the base where the Preuss red beds are absent. Mansfield's (1927, pp. 99-101) description of the Stump in the type locality is essentially similar except for the notable lack of the glauconite, though he mentions the presence of some green chloritic material.

The Stump and the Preuss together represent the lower portion of the Beckwith formation of Veatch (1907,p.57), a term no longer used.



MARINE JURASSIC SECTIONS
PLATE 3

<u>Nonmarine Jurassic and Lower Cretaceous formations</u>.--- Above the Marine Jurassic in Idaho and Wyoming is a series of conglomerates, sandstones, shales, and limestones of rather brightly variegated color. These have been related to the Morrison and part of the Cloverly formations of central Wyoming and the Gannett Group of Idaho. Apparently all the beds are of terrestrial or fresh water origin and hence contains few reliable markers for regional correlation. From Camp Davis westward a notable thickening of this series is observed. Eastward the thickness holds fairly constant, though the lateral variations in lithology are numerous and abrupt.

The most consistent horizon marker regionally in these beds is a sandstone which is very slightly limy, and usually weathers to a brilliant yellow or somewhat rusty color. Locally it is conglomeratic with chert pebbles up to half an inch in diameter and nearly everywhere it is exposed a few pebbles may be found in it. Secondary quartz is so abundant and characteristic that it is often referred to as the "quartz crystal sandstone". This unit can be traced over most of the Wind River Basin (Love, et al, 1945a) and westward as far as Dell Creek and the Gros Ventre River. It appears to be represented on Fall Creek (Chart VI p.37 and Plate 4) and further investigation may reveal its presence still farther west. The conglomerate probably marks the base of the Cloverly formation and of the Lower Cretaceous. Stratigraphically it appears to fall below a limestone here correlated with the Peterson limestone of the Gannett Group (Plate 4). This interpretation is strengthened by Imlay (1945) who states that the Ephraim Conglomerate(lowermost Gannett) is of Upper Jurassic age at least in part, (giving, however, no reasons for his conclusion) and Peck (1941) who places the Peterson limestone (overlying the Ephraim) in the Lower Cretaceous on the basis of its microfauna.

A series of alternating shales and sandstones lies below this bed. The sandstones are usually a light gray to gray green, and are frequently conglomeratic in their lower portions with angular fragments of green shale which were apparently reworked from the underlying shale unit. The shales are normally maroon or red, but their upper portions are often a light green color, apparently due to surface weathering prior to deposition of the overlying units. On the whole, the sequence is extremely variable, grading from dominantly sandy in some localities to dominantly shaly in others.

Above the "quartz crystal sandstone" shales and clays comprise most of the section. These are of a lighter color than the shales below, violets and grays being the common hues. In the Camp Davis area few sandstones are found in this part of the section, but in the Wind River Basin the lower half of this unit contains many lenticular sandstones and conglomerates similar to the "quartz crystal sandstone". There the shales are much more brilliantly variegated, with lilac and heliotrope shades which make this unit recognizable from a considerable distance. However, in the Camp Davis area limestones are found which apparently represent the Peterson and perhaps the Draney limestones of the Gannett Group of Idaho but which probably do not extend far east of the Camp Davis area.

In the Wind River Basin a series of the fine grained thin bedded gray sandstones and interbedded black shales have been placed in the top of the Cloverly (Love, et al, 1945a). They weather to a dark tan and have been called the "Rusty beds". These "Rusty beds" are gradational into the overlying "Thermopolis" black shale, and they are lithologically related to that unit. The "Rusty beds" and the "Thermopolis" shale appear to be equivalent to the Bear River formation of the Camp Davis area. It is the belief of this writer that the name Cloverly should be restricted to the variegated beds and the included sandstones. Together the Morrison and Cloverly would then be equivalent to the Gannett.

Dobrovolny (1941, p.433) placed the beds now called Stump and Gannett together in the Beckwith formation, following Veatch's (1907) and Schultz's (1914) usage, but recoginzing that their division was possible. The Stump-Gannett contact is not gradational, but for a few feet above the recognized Stump marine and non-marine sediments interfinger. It is therefore locally difficult to place the contact exactly, although usually it can be located within a few feet. (Chart V, p. 33-34).

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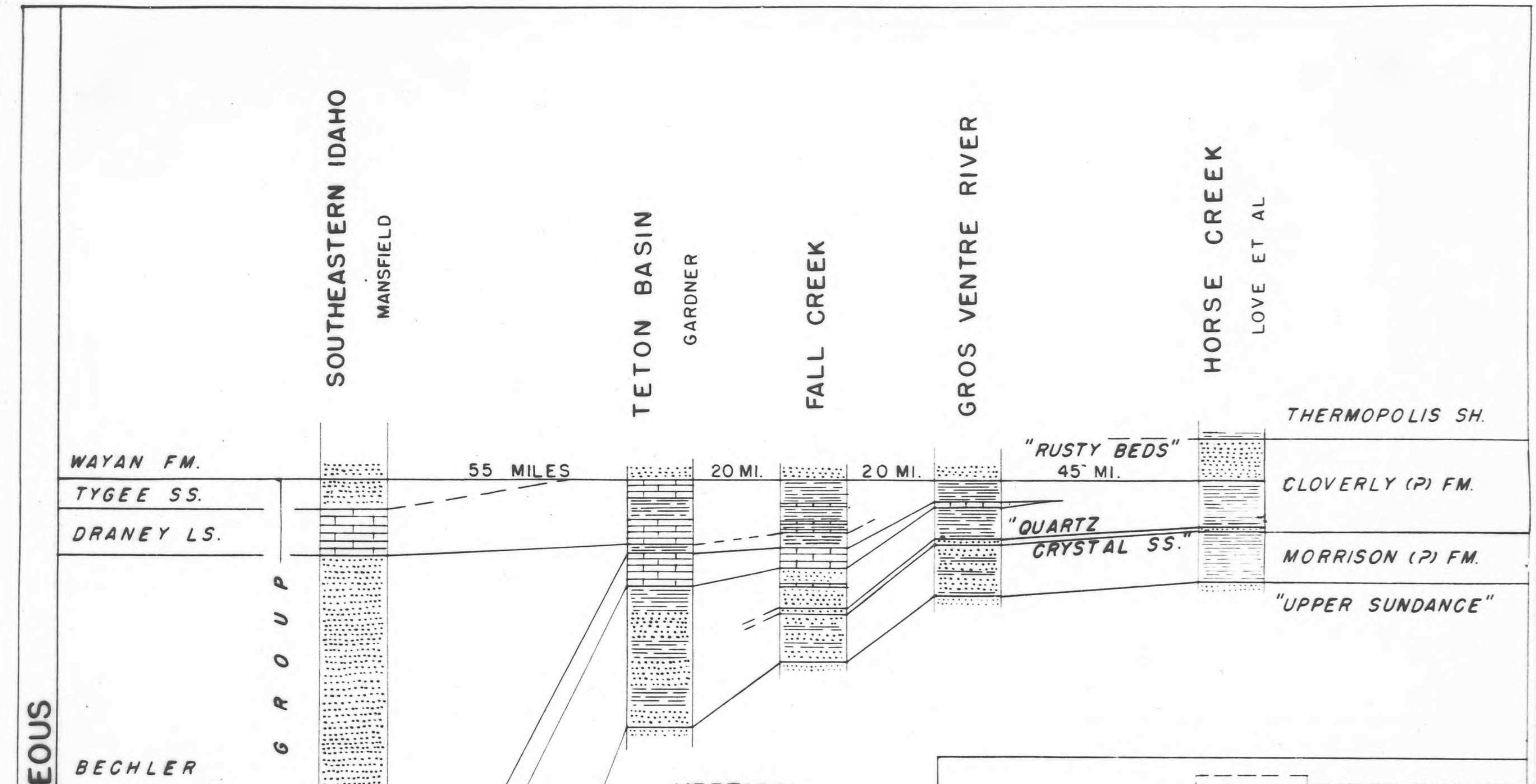

SOUTHEASTERN IDAHO
MANSFIELD
TETON BASIN
GARDNER
FALL CREEK
GROS VENTRE RIVER
HORSE CREEK
LOVE ET AL
JURASSIC
LOWER CRETACEOUS
WAYAN FM.
TYGEE SS.
DRANEY LS.
BECHLER CONGL.
PETERSON LS.
EPHRAIM CONGL.
STUMP. SS.
GANNETT GROUP
55 MILES
20 MI.
20 MI.
"RUSTY BEDS"
45 MI.
"QUARTZ CRYSTAL SS."
THERMOPOLIS SH.
CLOVERLY (?) FM.
MORRISON (?) FM.
"UPPER SUNDANCE"
VERTICAL SCALE
1500
1000
500
FEET
INDEX MAP
SHOWING LOCATION OF SECTIONS
HORSE CREEK
GROS VENTRE RIVER
TETON BASIN
FALL CREEK
SOUTHEASTERN IDAHO
IDAHO
UTAH
WYOMING
NON-MARINE JURASSIC AND LOWER CRETACEOUS SECTIONS
PLATE 4
H. Gray
5/22/46

Problems of nomenclature.--- Among the Jurassic formations of the Camp Davis area the Nugget sandstone alone presents no problem of nomenclature. It has been well established in the literature both to the east and to the west, and is present throughout the Camp Area.

The Twin Creek of Idaho is represented in part by the Gypsum Spring and the "Lower Sundance" formations. Gypsum Spring may prove useful still further west, as it can be recognized through the entire camp area. Considerable additional work is necessary to discover whether the expansion of that part of the section is largely by thickening of the unit as a whole or by addition of basal beds. Since basal Twin Creek is older than Gypsum Spring, it appears that basal beds are interposed. It may be found advisable to propose a new name to repalce the unsatisfactory "lower Sundance" and perhaps raise Twin Creek to group status.

The Preuss is clearly recognized in part of the camp area, and may be represented farther east by the"Sundance red zone". Probably the name should be used only where the formation is useful for mapping purposes. The "Sundance red zone" seems hardly important enough to deserve even member status, and where the Preuss is poorly developed it might better be included in the "Lower Sundance". Stump sandstone appears to be applicable in this area, and probably the name should be extended eastward into the Wind River Basin in preference to "Upper Sundance".

Until the Morrison-Cloverly controversy is settled, it appears best to retain the name Gannett Group for the non-marine

Upper Jurassic and Lower Cretaceous. Gannett might be extended to apply to the Morrison and the non-marine portion of the Cloverly wherever they are not clearly separable. Where the component formations can be recognized, they should be separated as the formations of the Gannett group into the Morrison and Cloverly of the shelf facies, or the Ephraim, Peterson, Bechler, Draney and Tygee of the geosynclinal facies.

SEDIMENTATION AND INTERFORMATIONAL RELATIONSHIPS

General discussion.--- In Triassic and Jurassic times the geosyncline which existed in southeastern Idaho and the great shelf area which extended over most of Wyoming were occupied from time to time by the sea. Between the periods of marine sedimentation the area received sediments under marginal or even continental conditions, and was occasionally subjected to subaerial erosion.

Relationship of Permian to Triassic.--- Throughout Wyoming, southeastern Idaho, and northeastern Utah, the Triassic appears to rest conformably on the underlying Permian. Thomas (1934, p. 1695) reports no apparent break in eastern Wyoming; Mansfield (1927, pp. 85) notes that evidence of a hiatus is based principally on faunal differences; and Boutwell (1912,p. 51) states that the Woodside rests conformably on the Park City formation. Newell and Kummel, (1942, p. 945) however, state that the Dinwoody exhibits a marked overlap on the Permian. Furthermore, at many localities the chert at the Phosphoria-Dinwoody contact is a chalky white (Charts I & II, pp. 11,18) which would indicate weathering of the post-Permian surface. Perhaps the conformable relations noted by some are local and weathering occured over considerable areas, but it is probable that little erosion took place in the interval and it is evident that the beds were not folded.

Lower Triassic sedimentation.--- In the central part of the Idaho geosyncline, near Pocatello, marine deposition continued throughout Lower Triassic time. From this area the sea extended as far as eastern Wyoming during a small part of Dinwoody and in latest Thaynes (Alcova) times, but it normally occupied only the geosyncline. Several times, however, it reaches as far east as the Camp Davis area. The fluctuations seem to be largely of chemical conditions rather than of actual shorelines, as the red sediments seem to be marginal facies deposited under conditions of oxidation, whereas the tan facies were deposited under reducing conditions capable of supporting life in a normal marine environment. The clastic material in both facies is similar except for the stage of exidation of the iron. Thoms (1934, pp. 1692-1693) suggests that the hematite responsible for the red color was derived from residual red soils developed on adjacent positive areas. In normal marine environments the hematite would be reduced probably to a limonite, producing the tan color characteristic of the geosynclinal sediments.

The sediments seem to have been supplied largely from the west, because the coarser clastic material is reported there. Sandstones are common in the Lower Triassic of Idaho. In central Wyoming the dominant material is siltstone, and in eastern Wyoming shale was deposited. The sediments present in southeastern Idaho indicate a slow rather continuous uplift of a land area not far to the west.

<u>Middle or Upper Triassic sedimentation</u>.--- Mansfield, in southeastern Idaho, recognizes an unconformity between the Thaynes group and the overlying Timothy sandstone. Another unconformity separates the Timothy from the Higham grit. One of these, probably the lower, might separate the Lower Triassic and the Middle or Upper Triassic, but they have not been recognized outside southeastern Idaho, as far as can be learned.

All rocks above the known Lower Triassic appear to be of continental or fresh-water origin. Again redbeds are common, the only notable exceptions being the Deadman limestone, and the Popo Agie member of the Chugwater formation. The Deadman limestone suggests fresh water deposition. It is not fossiliferous. The Popo Agie is of continental origin and appears to have been a floodplain deposit. The phytosaurian fauna (Love, et al, 1945c) corroborates this supposition.

Relationship of Triassic to Jurassic.--- The Nugget sandstone rests upon Triassic rocks with apparent conformity. Isopach maps (Love, et al, 1945c) of the Triassic indicate, however, some gentle warping at the close of Triassic time. This is also apparent in the sections shown on Plate 1. In addition, the rocks below the contact frequently show extensive alteration (Charts I & II, pp. 9 & 16). The most marked example of this was noted on East Dell Creek where the siltstone immediately below the contact was irregularly reduced to a depth of twelve feet apparently from a red color to a deep green.

Normally the siltstones below the contact are red or ochre and the green color perhaps indicates the amount of weathering. The depth of alteration may represent extreme conditions rather than a great length of tome. Several units of the Popo Agie on West Dell Creek (Chart III, p. 16) exhibit the same characteristics, and with the numerous conglomerates they give ample evidence of the many unconformities present within the Popo Agie member itself, a typical feature of flood plain types deposits. Certainly these unconformities, which are quite local, represent only a short break in deposition, and there is no reason to suppose the post-Popo Agie interval to have been very long. Yet these sediments and their included unconformities probably represent all of Middle and Upper Triassic times, and perhaps even a part of Lower Jurassic.

Jurassic sedimentation.--- The Jurassic may be subdivided into three distinct sections; the Nugget sandstone, the marine Jurassic formations, and the Gannett group and its equivalents (which include a part of the Lower Cretaceous).

The Nugget sandstone appears to be a dune deposit locally reworked in playa lakes. These lakes probably supplied the calcite now found in geodes, the peculiar rounded sand calcite crystals, and local limestone lenses. It is possible that some of the cross bedding so conspicuous in the Nugget is not of aeolian origin, but most of it is strongly suggestive of wind depostion. At the close of Nugget time extensive reworking in probably fresh water occurred so that now the formation is regular in thickness.

The transition to marine sedimentation is everywhere sharp and pronounced. Over most of Wyoming no basal conglomerate seems to be present, but in the Camp Davis region evidences of a basal conglomerate were found (Charts IV, V, & VII, pp. 34, 35, & 43). This unconformity represents all of Bajocian time in the Camp Davis region and eastward. During most of this time a sea existed in southeastern Idaho which in succeeding Bathonian time extended to cover most of the shelf area of Wyoming and remained there until late Argovian time. In this sea the Twin Creek, Preuss, and Stump were deposited in thegeosyncline, and in the shelf area the Gypsum Spring and Sundance were laid down.

The Gypsum Spring is the oldest of the shelf facies formations. It has not thus far been traced distinctly into the geosyncline.

In the Camp Davis area it is entirely marine except perhaps for the red shales and basal breccias. Eastward the red shales thicken, and with the gypsum which appears as the breccia dies out they comprise most of the formation. Apparently these were deposited in basins cut off from the sea. The origin of the breccia found in the Gypsum Spring in this area and elsewhere is in dispute. It exists only where the gypsum is absent and the formation is thin. For this reason the theory of a collapse breccia has been proposed. However, collapse over such a large area is hard to conceive, and furthermore, the breccia seems to thicken toward the geosyncline where deposition of the gypsum necessary for collapse would not normally be expected. In addition, no deformation of the beds immediately overlying the breccia has been observed. For these reasons the possibility of an intraformational conglomerate must not be overlooked. However, the fragments are quite angular and no semblance of lamellar or flow structure is apparent indicating a rigidity of the limestone bed before brecciation not common in the usual "edgewise" conglomerates. Thin-section studies should shed some light on the subject. The Gypsum Spring formation wedges out to the southeast and is overlapped by the "Lower Sundance".

The "Lower Sundance" is a truly marine sequence, consisting of chemical and fine clastic sediments. The most typical deposit is a limy shale such as the Gryphaea shale. The sea was probably shallow and warm, for life was abundant over the entire Wyoming-Idaho area. Oolitic limestones are characteristic. The lowest oolite in the marine Jurassic section is a reliable marker for the bottom of the formation.

The Preuss sandstone reflected an abrupt elevation of the land mass to the west, which seems to have supplied the rather coarse clastic red sediments. Neely (1937, pp. 762-763) states that the Preuss formation represents a delta and this satisfactorily explains all the facts now known.

With the Stump deposition of rather coarse clastics continued, and the Camp Davis area and over the Wind River Basin a few local conglomerates with pebbles up to a quarter of an inch or so in diameter were deposited near the base of the formation. Many of these lenses are quite limy with coarsely crystalline calcite and fossiliferous. The ledges so produced are conspicuous, but quite local. A two foot unit of sandy limestone may lense out completely in less than half a mile. Glauconite is characteristic of this formation, and the lowest glauconite usually marks the base. The upper half of the sandstone contains much less lime and usually also less glauconite.

With many alternations of marine and marginal conditions the sea receded. For a few feet above the true Stump sandstone red shales locally alternate with sandstones nearly identical to those of the Stump. The contact with the Gannett is therefore, somewhat difficult to place. The sandstones above become more lenticular and massive and suggest continental origin. The sequence as a whole takes on a cyclical aspect. The typical alternation which is subject to mauch variation, seems to begin with deposition of a red shale. The shale was then subjected to some weathering, and a green color was developed in the upper few inches. Fragments of the weathered shale were then deposited in the base of the coarse sandstone unit which covered it. The cycle then begins anew with the deposition of mre red shale. Extreme lateral variations characterize the unit. This portion of the Gannett probably constitutes the Morrison formation.

Jurassic-Lower Cretaceous boundary.--- With little noticeable change the region passed over into the Lower Cretaceous period. The probable contact in this region, as in the Wind River Basin, is at the base of the "quartz crystal sandstone". (Love, et al, 1945a). The deposits of this part of the Gannett group, which probably represents the Cloverly formation, consist of rather light colored muds and clays and a few fresh water limestones, which probably represent the Peterson and perhaps the Draney limestones of the Gannett group. On the Gros Ventre River quantities of "gastroliths" have been found.

Above these continental sediments the "rusty beds" of central Wyoming and the basal Bear River sandstones of western Wyoming were deposited. Bothe the "Rusty beds" and the Bear River appear to have been deposited in brackish or fresh water.

References Cited

Baker, A.A., Dane, C.H., and Reeside, J.B.,Jr. (1936) Correlations of the Jurassic Formations of Parts of Utah, Arizona, New Mexico and Colorado, U.S. Geological Survey Professional Paper Number 183.

Blackwelder, E. (1918) New Geological Formations in Western Wyoming, Washington Academy of Science Journal Vol. 8, pp. 417-426.

Boutwell, J.M. (1907) Stratigraphy and Structure of the Park City Mining District, Utah, Journal of Geology Vol. 15, pp. 434-458.

-------- (1912) Geology and Ore Deposits of the Park City District, Utah, U.S. Geological Survey Professional Paper Number 77.

Condit, D.D. (1918) Relations of Late Paleozoic and Early Mesozoic Formations of Southwestern Montana and Adjacent Parts of Wyoming, U.S. Geological Survey Professional Paper Number 120F.

Darton, N.H. (1899) Jurassic Formations of the Black Hills of South Dakota, Geological Society of America Bulletin Vol. 10, pp. 383-386.

------ (1908) Paleozoic and Mesozoic of Central Wyoming, Geological Society of America Bulletin Vol. 19, pp.403-474.

Dobrovolny, E. (1941) Jurassic and Cretaceous Strata of the Camp Davis Area, Wyoming, Michigan Academy of Science, Arts, and Letters, Vol. 26, pp. 429-443.

Gardner, L.S. (1944) Phosphate Deposits of the Teton Basin Area, Idaho and Wyoming, U.S. Geological Survery Bull 944A.

Imlay, R.W. (1945) Occurence of Middle Jurassic Rocks in Western Interior Of United States, American Association of Petroleum Geologists Bulletin Vol. 29, pp. 1019-1027.

Love, J.D. (1939) Geology Along the Southern Portion of the Absaroka Range, Wyoming, Geol. Soc. Am. Special Paper 20.

----,et al (1945a) Stratigraphic Sections and Thickness Maps of Nonmarine Jurassic and Lower Cretaceous Rocks in Central Wyoming, U.S. Geol. Sur. Prelim. Chart 13.

---- -- -- (1945b) Stratigraphic Sections and Thickness Maps of Jurassic Rocks in Central Wyoming, U.S. Geol. Sur. Prelim. Chart 14.

Love, et al (1945c) Stratigraphic Sections and Thickness Maps of Triassic Rocks in Central Wyoming, U.S. Geol. Smr. Prelim. Chart 17.

Mansfield, G.R. (1920) Geography, Geology, and Mineral Resources of the Fort Hall Indian Reservation, Idaho, U.S. Geol. Sur. Bull. 713.

--------- (1927) Geography, Geology, and Mineral Resources of the Part of Southeastern Idaho, U.S. Geol. Sur. Prof. Pap. 152.

Neely, J. (1937) Stratigraphy of the Sundance Formation and Related Jurassic Rocks in Wyoming and Their Petroleum Aspects, Amer. Assoc. Pet. Geol. Bull., Vol 21, pp. 715-770.

Newell, N.D., and Kummel, B. (1942) Lower Eo-Triassic Stratigraphy Western Wyoming and Southeastern Idaho, Geol. Soc. Am. Bull. Vol. 53, pp. 937, 996.

Peck, R.E. (1941) Lower Cretaceous Rocky Mountain Microfossils, Journal of Paleontology, Vol. 15, pp. 285-304.

Richmond, G.M. (1945) Geology of Northwest end of the Wind River Mountains, Sublette County, Wyoming, U.S. Geol. Sur. Prelim. Map 31.

Schultz, A.R. (1914) Geology and Geography of a Portion of Lincoln County, Wyoming, U.S. Geol. Sur. Bull. 543.

St. John, O. (1883) Twelfth Annual Report, U.S. Geological and Geographical Survey of the Territories, Pt. 1.

Thomas, H.D. (1934) Phosphoria and Dinwoody Tongues in Lower Chugwater of Central and Southeast Wyoming, Amer. Assoc. Pet. Geol. Bull. Vol. 18, pp. 1655-1697.

Veatch, A.C. (1907) Geography and Geology of a Portion of Southwestern Wyoming, U.S. Geol. Sur. Prof. Pap. 56.