THE GEOLOGICAL SURVEY OF WYOMING

HORACE D. THOMAS, State Geologist

REPORT OF INVESTIGATIONS NO. 8

STRATIGRAPHIC SECTIONS OF UPPER JURASSIC AND LOWER CRETACEOUS ROCKS IN THE SOUTHERN BIGHORN MOUNTAINS, WYOMING

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INTRODUCTION

Twenty detailed stratigraphic sections of Upper Jurassic and Lower Cretaceous rocks were measured in the southern part of the Bighorn Mountains in north-central Wyoming (Table 1). The area studied includes southwestern Johnson County, southeastern Washakie County, and northwestern Natrona County (Fig. 1). It lies approximately between latitudes 43° 03'N and 43° 14'N and longitudes 106° 45'W and 107° 35'W, and contains Townships 38 to 47 N., and Ranges 83 to 89 W.

The study was undertaken in order to investigate the stratigraphic relations, lithologic characteristics, and sedimentary history of the nonmarine Upper Jurassic and Lower Cretaceous rocks. The stratigraphy has been discussed in detail in a paper submitted for publication in the Bulletin of the American Association of Petroleum Geologists, and the results of the mechanical analysis and heavy mineral studies were presented in a paper submitted to the Journal of Sedimentary Petrology scheduled to appear in the December, 1961, or March, 1962, issue.

The stratigraphic section underlain by the marine Sundance formation and overlain by the lower black shale unit of the marine Thermopolis shale is preponderantly nonmarine. It is divisible into four natural mappable units. They may be briefly described from bottom to top as follows. Unit 1 is essentially a variegated mudstone with gray-green predominating over shades of red. Small conglomeratic channel sandstones locally occur at any position in the unit but normally are in the middle part. Unit 2 is essentially a white to gray cross-bedded sandstone which is conglomeratic in many places. Despite its variable thickness, from 4 to 90 feet, it is mostly resistant to erosion and is traceable along the eastern and western flanks of the Bighorn Mountains. Unit 3 is essentially a variegated mudstone like unit 1, but shades of red predominate over green. This unit includes soft sandstone lenses throughout and, locally, thin resistant sandstone beds at the top; it is absent at many places on the eastern flank of the mountains. Unit 4 is black papery

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* Institute of Polar Studies, Ohio State University, Columbus, Ohio.

NO.	NAME	LOCATION		
		SECTION	T.	R.
1	East Red Fork Powder River (J)*	S SE 26	43N	83W
2	Middle Fork Powder River (J)	S NE 33, NW SW 34	43N	83W
3	West Red Fork Powder River (J)	SW NE 34	43N	83W
4	East Barnum (J)	W NW 32	43N	83W
5	West Clark Ranch (J)	NW NE 23	43N	83W
6	Pass Creek (J)	NW 24	44N	83W
7	Northwest Clark Ranch (J)	S SW 11	43N	83W
8	Northeast Arminto (N)	NE NW 19	38N	86W
9	North Arminto (N)	S SE 10	38N	87W
10	Baker Cabin Road (N)	E NW, W NE, SE 25	39N	86W
11	Alkali Creek (N)	NE NE, NE SE 4	39N	83W
12	Spring Creek (W)	NE 19, NW 20	46N	87W
13	Otter Creek (W)	NE 7, NW 8	45N	87W
14	Tensleep (W)	SW 24	47N	89W
15	North Big Trails (W)	SE 19, S 20	45N	87W
16	South Big Trails (W)	NW 25	43N	88W
17	Nowood (W)	SE 19 (?)	42N	88W
18	Mayoworth (J)	NE 33, NW 34	45N	83W
19	Willow Creek (N)	SW 2, SE 3	40N	83W
20	Southeast Barnum (J)	NW 17	42N	83W

* (J)--Johnson County; (N)--Natrona County; (W)--Washakie County

Table 1. Names and locations of measured sections, southern Bighorn Mountains, Wyoming.

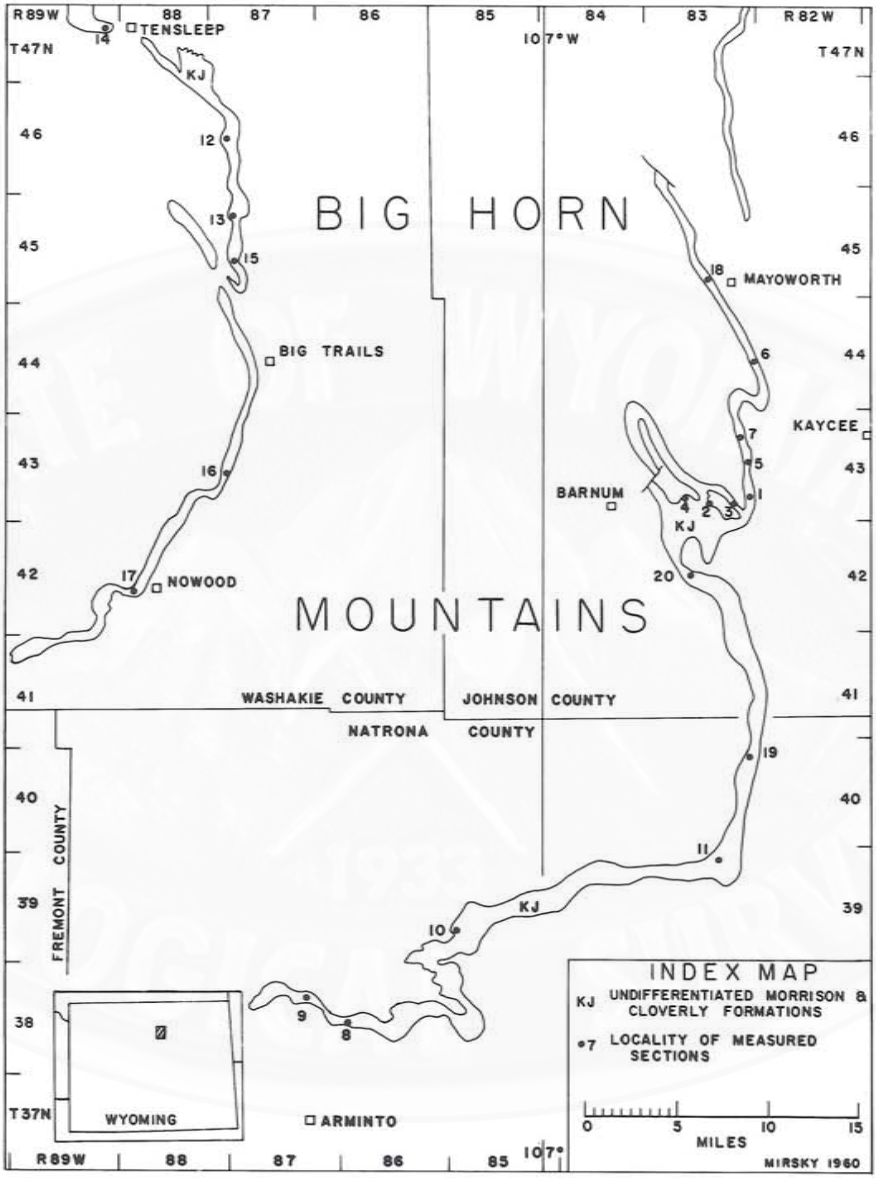

Figure 1. Index map showing location of measured sections.

shale interbedded with thin lenticular cross-laminated siltstones and sandstones. This unit is both nonmarine and marine in origin and intertongues with the overlying Thermopolis shale.

The lower mudstone (unit 1) is recognized as the Morrison formation; the distinctive white sandstone (unit 2) and the overlying upper mudstone (unit 3) as the Cloverly formation; and the upper black shale and siltstone (unit 4) as the basal Thermopolis shale. Because of the distinctiveness and continuity of the white sandstone forming the lower part of the Cloverly formation, this unit has been named the Otter Creek sandstone member of the Cloverly*, the type section being along Otter Creek in T. 45 N., R. 87 W., (see Section 13). It is not suggested that the term Otter Creek be applied to the basal conglomeratic sandstone in the Cloverly formation elsewhere in the Bighorn Mountains. The term is simply a functional one for identifying this characteristic part of the section in the southern part of the Bighorn Mountains and, perhaps, for a short distance into the subsurface of the adjacent Bighorn and Powder River Basins. The upper part of the Cloverly is not named because of its generally poor exposures and absence in many places along the eastern side of the area, but it is simply referred to as the Mudstone member of the Cloverly. Unit 4, although variously placed in the uppermost Cloverly or lowermost Thermopolis by previous investigators, has been informally known as the "Rusty Beds" for a long time, and the term is ingrained in the literature. It has been proposed that this unit formally be named the Rusty Beds member of the Thermopolis shale.

The Morrison formation is somewhat sandier and the Otter Creek member of the Cloverly is thicker and more conglomeratic on the western flank of the Bighorn Mountains than on the eastern flank, suggesting a western source area for both units. A plot of cross-bedding directions, however, shows that the source of the Morrison was southwest. Both the Morrison and the Cloverly have essentially the same heavy-mineral suite, indicating that they were derived from the erosion of older sedimentary rocks, but in passing from the Morrison to the Cloverly there is an abrupt increase in percentage of rounded zircon and a concomitant decrease in garnet.

The contact between the Morrison and the Cloverly appears to represent a hiatus, but it does not necessarily correspond to the Jurassic - Cretaceous boundary. The hiatus is suggested in part by a combination of the differences in cross-bed orientation and the zircon-garnet relationship.

The contact between the Otter Creek and Mudstone members of the Cloverly formation is not well understood because of the generally poor

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* The names (1) Otter Creek sandstone member of the Cloverly formation, (2) Mudstone member of the Cloverly formation, and (3) Rusty Beds member of the Thermopolis shale were first proposed in the writer's doctoral dissertation at the Ohio State University in 1960, and were established by publication in Dissertation Abstracts, Vol. XXI, No. 4, October, 1960, pp. 850-51. These units will be further defined in a paper submitted for publication in the Bulletin of the American Association of Petroleum Geologists.

exposures. The contact appears even and conformable at many places, but channeling of the Mudstone member into the Otter Creek member occurs at other places. Evidence of intertonguing may exist at measured Section 11 on the southeast side of the Bighorn Mountains. The implication that the two members may be more nearly facies equivalents than successive deposits is in accord with the observation that the few cross-bed orientations noted in the Mudstone member suggest a source from the northeast, which is opposite to the source indicated for the Otter Creek member. More evidence is needed to substantiate this concept.

The contact between the Cloverly formation and the Rusty Beds member of the Thermopolis shale is an unconformity. It is because of the unconformity, and because the tidal flat origin of the Rusty Beds member genetically relates it to the marine Thermopolis shale rather than to the nonmarine Cloverly, that the Rusty Beds nas been included as the basal unit of the Thermopolis rather than as the upper unit of the Cloverly.

One of the results of this study is that the Morrison and Cloverly formations, which constitute the nonmarine section, can be recognized in this area as discrete units. Many previous workers have been reluctant to differentiate the nonmarine section into these two formations. A major reason for this caution appears to be disagreement regarding the placement of the Morrison-Cloverly contact. If the upper limit of the Morrison is considered to coincide with the Jurassic-Cretaceous boundary, which need not be so, then the contact must always be in doubt and the nonmarine section properly must be referred to as undifferentiated Morrison-Cloverly. However, if the two formations are considered only as physical units, it is believed that it is possible to distinguish between the Morrison and Cloverly in this area by noting gross lithology, cross-bed orientation, the geometry of the conglomeratic sandstones, and the heavy mineral content (specifically, zircon and garnet).

SECTION 1: EAST RED FORK POWDER RIVER

Section measured about 0.5 mile north of where Kaycee-Barnum road crosses Red Fork Powder River, on east side of river. Section begins in Sundance formation in S 1/2 SE 1/4 sec. 26, and continues eastward up slope; offset section begins in Otter Creek sandstone member of Cloverly formation about 0.3 mile eastward at a point about 500 feet north of the section corner common to secs. 25, 26, 35, and 36, T. 43 N., R. 83 W., Johnson County, Wyoming. Measured with Brunton and tape. Strike: N 10° E; dip: 6° S 80° E.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

21. Shale, blue-black

Rusty Beds member: 98 feet thick

20. Shale, black, paper-thin, with interbeds and lentils of tan, gray, and brown, thin-bedded and cross-laminated highly lenticular siltstone to very fine sandstone, having very coarse grains along bedding; forms slope; siltstone and very fine sandstone become more prominent upward so that uppermost 8 feet is moderately resistant, ledge-forming shaly siltstone to very fine sandstone; rusty stain along bedding surfaces and fractures locally; heavy rusty stain in uppermost 1 to 2 feet..... 56.0

19. Shale, black, paper-thin to thin-bedded, with minor siltstone, tan, gray, and brown, cross-laminated and thin-bedded, highly lenticular, with very coarse grains along bedding; forms slope; several bentonitic (?) beds..... 42.0

UNCONFORMITY

Cloverly formation: 28 feet thick

Otter Creek sandstone member

18. Sandstone, white, very fine to coarse, subround, generally poorly sorted moderately to well cemented, low-angle cross-bedded; sparkly, sugary; forms ledge; polished pebbles occur as float on upper surface, which is slightly undulating; directly overlain by Rusty Beds member at measured section, but about 200 feet southward it is overlain by 9 feet of lavender to red mudstone of Mudstone member of Cloverly; this unit forms rim at top of main slope and is bottom of offset section..... 28.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 230 feet thick

17. Mudstone, green with purple; slope..... 87.0
16. Mudstone, red with green; slope..... 24.0
15. Sandstone, gray, very fine to fine, subround, well sorted to moderately sorted, well cemented, with cross-bedding inclined toward N75°E; includes green mudstone fragments up to 0.5 inch thick, scattered black chert grains, and ferruginous nodules; sparkly; thins out eastward within a few hundred feet (see Fig. 2)..... 8.0

(14. Mudstone, olive-green; covered slope; lateral equivalent of units 10 to 13)

13. Siltstone to very fine sandstone; similar to unit 11..... 1.0
12. Mudstone, green with red-brown spots, streaks, zones, and mottling, calcareous; breaks in massive pieces; slope..... 20.0
11. Sandstone, gray, very fine, subangular, well cemented, with small-scale cross-bedding with variable dips; sparkly; with limonite stain; ledge..... 2.0
10. Mudstone, olive-green; slope..... 3.0
9. Sandstone, gray, fine, well cemented, very slightly calcareous in places; sparkly..... 0.5
8. Sandstone, gray, fine, subround, moderately cemented, calcareous; includes resistant calcified nodules and coalified wood fragments; slope..... 5.0
7. Sandstone, gray-green, very fine, subround to round, poorly cemented, calcareous, with small-scale cross-bedding; slope..... 8.0
6. Siltstone, dark-red with green streaks and spots, calcareous; upper 3 feet is a sandstone, gray-green, very fine, poorly cemented, calcareous, with interbedded red, calcareous mudstone, in layers less than 0.25 inch thick; slope..... 19.0
5. Sandstone, gray, very fine, subround, well sorted, poorly cemented, calcareous, with small-scale cross-bedding; includes ferruginous nodules up to 0.5 inch in diameter occurring in layers which parallel bedding but

are randomly distributed and non-calcareous 11.0

4. Siltstone, gray, calcareous, with interbedded mudstone, dark-green, calcareous, in layers less than 0.25 inch thick; soil covered slope 3.0
3. Sandstone, similar to unit 5, but sparkly and with sparsely scattered black chert grains 3.5
2. Mudstone to siltstone, pale green with pale red zones, streaks, and mottling, calcareous; breaks in massive pieces; upper part silty; sparkly; slope 6.0
1. Sandstone, gray to gray-green, very fine, subround, poorly to moderately cemented, very to slightly calcareous, cross-bedded; includes minor amounts of angular to rounded light brownish-red (garnet?) and black and dark-green (glauconite) grains; cross-bedding is generally poorly defined unless brought out by weathering; several 2-foot cross-bed sets near top have beds inclined about 24° toward N80° E; a silicified log (and fragments) occurs 2 feet above base, strikes N45°E; small bone fragments occur at base of upper cliff (8 feet above base of unit); unit forms a lower cliff 6 feet high, an upper cliff 21 feet high, with a shaly sandstone undercut between; basal foot contains some reworked Sundance; laterally, unit grades into a mudstone section (see Fig. 2) 29.0

Total Morrison and Cloverly 258.0

DISCONFORMITY: Sundance-Morrison contact is slightly irregular, but at one place the relief is 5 feet.

Sundance formation: (in part)

Limestone, gray, sandy, glauconitic, many shell fragments, resistant ledge 6.0

SECTION 2: MIDDLE FORK POWDER RIVER

Section measured on prominent projection of rim on north side of river. Section begins in Sundance formation in S 1/2 NE 1/4 sec. 33 and continues eastward up slope; offset section begins at base of Rusty Beds member of Thermopolis shale about 0.25 mile N80° E in NW 1/4 SW 1/4 sec. 34, T. 43 N., R. 83W., Johnson County, Wyoming. Measured with Brunton and tape. Strike: N 35° W.; dip; 10°N 55° E.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

26. Shale, blue-black

Rusty Beds member: 90 feet thick

25. Shale and siltstone, similar to unit 20 at section 1 ..... 37.0
24. Shale and siltstone, similar to unit 19 at section 1, but with mustard yellow stain as well as rusty stain along bedding surfaces and fractures 53.0

UNCONFORMITY

Cloverly formation: 22 feet thick

Otter Creek sandstone member:

23. Sandstone, white to gray, fine to coarse, moderately cemented, with cross-bedding inclined 11° toward N45°E; locally sparkly and has ferruginous nodules; 4-foot white siltstone lense near top; bottom surface highly irregular and channeled into Morrison; top surface slightly undulating and shows ripples; forms ledge and rim of bench at top of slope; polished pebbles occur as float on lower slope of bench and in place in conglomeratic uppermost few inches of unit, where some conglomeratic fragments are up to 6 inches in diameter; conglomeratic basal part of unit has white chert grains; thickness quite variable; average 22.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 231 feet thick

22. Sandstone, white, very fine, thin-bedded; sparkly 1.0
21. Mudstone, pale green, bentonitic 47.0
20. Mudstone, olive-green to dark-gray, silty with sparsely scattered very coarse rounded grains; contains dis-continuous layers of highly fractured

agatized dinosaur (?) bones; slope..... 6.0
19. Mudstone, drab-green, mottled with red to purple; slope..... 11.0
18. Mudstone, pale green, bentonitic, slope..... 26.0
17. Sandstone, gray, very fine, subround, poorly cemented, with cross-bedding in sets up to 2 feet inclined 24° toward S80° E; sparkly, porous; ferruginous nodules up to 2 inches in diameter occur randomly throughout, and limestone nodules up to 8 inches in diameter occur randomly in upper part; includes pale gray-green mudstone fragments; locally stained mustard yellow and tan; selenite veinlets in lower part; channel sand about 15 feet thick at center, about 30 feet wide in main part, thins to a few feet outside main part and thins out within 100 feet on both sides..... 15.0
16. Mudstone, gray-green, silty, grading into gray siltstone in upper foot, both containing selenite veinlets and mustard yellow iron stain (jarosite?); sparkly, massive; siltstone contains occasional very coarse rounded and angular quartz and black chert grains..... 4.0
15. Siltstone, similar to unit 13, but upper half is more a silty mudstone and darker gray-green..... 21.0
14. Siltstone or very fine sandstone, gray, well cemented, calcareous; medium to very coarse grains scattered throughout; massive rounded ledge..... 1.5
13. Siltstone, gray-green; very coarse grains scattered throughout; slope..... 8.0
12. Siltstone, red-brown with green spots, zones, streaks, and mottling, calcareous; sparkly; slope..... 32.0
11. Sandstone, similar to unit 8 but forms rim of a bench, though it thins in both directions and goes into slope..... 1.0
10. Siltstone, light red-brown, slightly calcareous; sparkly, slope..... 7.0
9. Siltstone, gray-green, slightly calcareous; sparkly; slope..... 4.0
8. Sandstone, gray, fine, moderately cemented, calcareous, with small-scale cross-bedding; sparkly, clean with only very minor amounts of chert grains; almost flaggy..... 2.0
7. Mudstone, similar to unit 5 but much more silty; sparkly..... 12.0
6. Sandstone, gray, fine, well cemented, calcareous, with very low-angle cross-bedding inclined toward S85°E (?); current ripple marks strike N10°E; forms ledge and rim of bench..... 2.0
5. Mudstone, red-brown, silty, slightly calcareous; slope..... 7.0
4. Sandstone, similar to unit 3, but moderately cemented and forms ledge..... 1.0
3. Sandstone, gray, very fine, poorly cemented, calcareous, with parallel - to cross-bedding; forms slope..... 18.0
2. Sandstone, gray, fine, calcareous, with small-scale cross-bedding; sparkly; resistant lens 8 feet long..... 0.5
1. Sandstone, gray to green-gray, fine to very fine, moderately cemented, calcareous, with small-scale cross-bedding; contains glauconite and black chert grains..... 4.0

Total Morrison and Cloverly 253.0

DISCONFORMITY

Sundance formation: (in part)
Limestone, gray, with shell fragments at base grading up into dark-gray, finely crystalline limestone; cross-bedded and glauconitic throughout..... 4.5
Sandstone, gray-green, very fine, glauconitic, calcareous.

SECTION 3: WEST RED FORK POWDER RIVER

Section measured about 0.5 mile north of where Kaycee-Barnum road completes first big (180°) curve after crossing Red Fork Powder River, or about 0.67 mile west of where the road crosses the River. Section begins in Sundance formation in SW 1/4 NE 1/4 sec. 34, T. 43 N., R. 83 W., Johnson County, Wyoming. Measured with tape. Strike: N 20° W; dip: S 70° W.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part) covered

UNCONFORMITY
Cloverly formation: about 30 feet thick
Otter Creek sandstone member
24. Sandstone, white, medium to coarse, moderately cemented, cross-bedded; tan and rusty stains and streaks throughout; includes some white chert

grains and some kaolinized feldspar; approximately 30.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 249 feet thick

23. Mudstone, light green to dark gray-green, with dark red-brown to purplish tinge; mostly under soil cover; estimated 50.0
22. Sandstone, light gray, very fine, well cemented, calcareous, clean; resistant 0.5
21. Mudstone, olive-green and red-brown; mostly soil and rubble cover 43.0
20. Sandstone, gray, very fine, moderately cemented, cross-bedded, calcareous; forms hogback 3.0
19. Siltstone, gray, very small-scale cross-bedding, calcareous; soft, forms slope 7.0
18. Sandstone, gray, medium, moderately cemented, low-angle cross-bedding, splits into sets 3 to 8 inches thick, average 5 inches, calcareous; with limonite specks 4.0
17. Sandstone, tan-gray, fine, irregular flaggy bedding, calcareous; slope 6.0
16. Sandstone, gray, medium to coarse, moderately cemented, calcareous, low-angle cross-bedded; limonite specks; hogback 4.0

15a Covered slope with sandy soil 18.0

15. Sandstone, white, fine, moderately cemented, calcareous small-scale cross-bedded; sparkly, sugary; yellow iron staining; hogback 2.0
14. Slope with red soil, probably similar to unit 13 ..... 28.0
13. Mudstone, light green and red-brown, silty, calcareous; slope 2.0
12. Sandstone, green-gray, very fine, calcareous, laminated bedding; moderately resistant 2.0
11. Siltstone, red-brown, calcareous, very thin-bedded to laminated; slightly sparkly; soil-covered slope 8.5
10. Sandstone, similar to unit 2, but sparkly and lesser amounts of black and orange chert grains; variable thickness; average 3.0
9. Mudstone, red-brown with olive-green zones in places, silty, calcareous; slope 11.0
8. Mudstone to siltstone, gray-green, calcareous; very minor black and orange chert grains; mostly covered slope; approximately 8.0
7. Sandstone, similar to unit 5 but about 600 feet long 4.0
6. Slope with soil and rubble cover, probably similar to unit 4 ..... 10.0
5. Sandstone, white, fine to coarse; similar to unit 2 but well cemented and forms hogback; less than 100 feet long 0.5
4. Sandstone, gray, fine; similar to unit 2 but soft; unit 3 may be part of same 7.0
3. Slope with soil and rubble cover 13.0
2. Sandstone, gray, fine, moderately cemented, calcareous, very small-scale cross-bedded; minor amount of angular black and orange chert grains; poor hogback 3.5
1. Sandstone, green-gray, very fine, poorly cemented, calcareous, porous, small-scale cross-bedded; includes black chert grains, lesser orange chert grains, and thin-bedded sandstone layers which is similar but medium and sparkly; slope 11.0

Total Morrison and Cloverly 279.0

DISCONFORMITY

Sundance formation: (in part)

Limestone, gray, with shell fragments, grading upwards to finely crystalline sandy limestone; cross-bedded on very small scale 4.0

SECTION 4: EAST BARNUM

Section measured three miles east of Barnum, and about 1000 feet north of where Kaycee-Barnum road crosses Middle Fork Powder River via a metal bridge at junction with Beaver Creek. Section begins at river level on the north undercut bank within the Morrison formation in W 1/2 NW 1/4 sec. 32, and continues northward up slope; offset begins in Otter Creek sandstone member of Cloverly formation about 0.25 mile west in E 1/2 NE 1/4 sec. 31, T. 43 N., R. 83 W., Johnson County, Wyoming. Measured with Brunton and tape. Strike: E-W, swinging

northeastward at offset; dip: 5° northward, swinging northwestward at offset.

	Feet
LOWER CRETACEOUS	
Thermopolis shale: (in part)	
29. Shale, blue-black	
Rusty Beds member: 95 feet thick	
28. Shale, black, and siltstone and sandstone, similar to units 19 and 20 at section 1	95.0
UNCONFORMITY	
Cloverly formation: 19 feet thick	
Mudstone member: 11 feet thick	
27. Sandstone, gray to tan, very fine to coarse, well cemented, very low-angle cross-bedded to thin-bedded: includes ferruginous nodules and red and brown ferruginous staining; blocky, resistant; thins out within 100 feet northeastward, goes underground westward	2.0
26. Mudstone, shades of green and red, soft, shaly in small pieces; slope; very variable in thickness; occurs in channel cut into unit 25 at main section, but over-lies unit 25 conformably at offset section; the thickness recorded is that at offset	9.0
Otter Creek sandstone member: 8 feet thick	
25. Sandstone, white, fine to coarse, moderately cemented, cross-bedded, slightly calcareous in places; includes rounded smoky quartz grains, subangular white chert and some kaolinized feldspar grains; with yellow, tan, and rusty stains and zones, and ferruginous nodules; bottom surface irregular and thickness very variable; prominent ledge; at offset, cross-bedding at top inclined 28° N35°W, and a 4-foot-thick cross-bed set 400 feet eastward is inclined 26° toward N15°W; polished pebbles occur as float at offset	8.0
DISCONFORMITY	
UPPER JURASSIC	
Morrison formation: incomplete thickness, 172 feet	
24. Mudstone, gray-green, silty; grades up from unit 23; slope	7.0
23. Siltstone, dark gray-green; includes angular black chert (?) grains up to coarse sand size; rusty stains along fractures; ledge	2.0
22. Mudstone, dark gray-green, silty; includes angular coarse black chert (?) grains; rusty stains along fractures; slope	11.0
21. Siltstone, green-gray, well cemented; includes angular coarse black chert (?) grains; resistant	0.5
20. Mudstone, olive-green, bentonitic; bare slope with many agatized dinosaur (?) bones as float, and occurring as thin discontinuous layers of bone fragments	44.0
19. Mudstone, purple and green, silty, bentonitic (?); slope	9.0
18. Sandstone, gray, fine to medium, well cemented; sparkly because of inclusion of large crystals of calcite which enclose sand grains; calcareous; includes coarse angular black chert (?) grains; resistant	1.0
17. Mudstone, dark gray with green, silty; slope	7.0
16. Sandstone, gray, very fine, well cemented, calcareous; includes minor orange and red chert grains; resistant	1.0
15. Siltstone, light olive-green, calcareous; slope	3.0
14. Mudstone, red-brown and green, silty, calcareous; slope	15.0
13. Limestone, gray, finely crystalline; includes pale green streaks, and black chert grains; thins out about 50 feet northeastward, goes under soil cover southward; forms rim of small bench	2.0
12. Mudstone, red-brown with light green zones, silty, calcareous; slope	19.0
11. Sandstone, similar to unit 10, but forms a ledge	1.0
10. Sandstone, gray-green, very fine, poorly cemented, calcareous, small-scale cross-bedded; slope	3.0
9. Sandstone, gray, very fine, moderately cemented, calcareous, small-scale cross-bedded; ledge	1.0
8. Mudstone, red-brown and pale green, silty, calcareous; slope	5.0
7. Sandstone, gray, fine, well cemented, calcareous small-scale	

cross-bedded; includes some ripple marks 2.0

6. Siltstone, drab green, calcareous, very small-scale cross-bedded; mostly under soil cover; about 3 feet of red silty mudstone seems to occur beginning at 10 feet above base of unit; slope 15.0
5. Siltstone, gray-green, calcareous, very small-scale cross-bedded; slope 2.5
4. Sandstone, gray, fine, well cemented, calcareous, small-scale cross-bedded; variable thickness 0.5
3. Sandstone, gray, very fine, soft, calcareous, very small-scale cross-bedded and laminated; coalified wood fragments occur along bedding surfaces; slope 3.5
2. Sandstone, gray, fine, well cemented, calcareous, with cross-bedding inclined 21° toward N50°E; includes some ferruginous nodules; channels into unit 1 below; sparkly; ledge 13.0
1. Mudstone, olive-green, calcareous; slope; begins at river level so thickness is minimum 4.0

Incomplete Total Morrison and Cloverly 191.0

SECTION 5: WEST CLARK RANCH

Section measured about 1.5 miles N80°W of Clark Ranch. Section begins in Sundance formation in NW 1/4 NE 1/4 sec. 23, T. 43 N., R. 83 W., Johnson County, Wyoming. Measured with Brunton and tape. Strike: N 15° W; dip: 8° N 75° E.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

20. Shale, black

Rusty Beds member: 93.5 feet thick

19. Sandstone, dark gray-green, very fine to siltstone, shaly, cross-laminated; includes minor black shale which decreases upward to occasional paper-thin layers; uppermost two feet is stained a chocolate, and is moderately resistant 26.0
18. Shale and siltstone, similar to unit 16 ..... 48.0
17. Siltstone, red-brown, extremely hard and resistant concretionary layer similar to unit 15 ..... 1.0
16. Shale and siltstone, similar to unit 14, but with fine sandstone and rusty staining 11.0
15. Siltstone, red-brown, extremely hard and resistant concretionary layer about 3 feet long; lenticular, splits as though along irregular bedding 0.5
14. Shale, black, and siltstone, brown, similar to unit 19 at section 1 (that is, typical lower Rusty Beds); includes 2-inch-thick, poorly sorted, coarse sandstone a few inches above base of unit; slope 7.0

UNCONFORMITY

Cloverly formation: 12 feet thick

Otter Creek sandstone member

13. Sandstone, white, fine to coarse, poorly cemented, slightly calcareous in places, very small-scale cross-bedded (sets less than 6 inches thick, and average 2 inches); includes white chert and some kaolinized feldspar grains; locally stained rusty, tan, and yellow; polished pebbles occur in place at top; at one locality, a 1-foot-thick cross-bed set is inclined toward N60°W; locally sparkly; looks shaly from distance; forms prominent ridge; variable thickness and irregular bottom surface 12.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 228 feet thick

12. Mudstone, blackish red-brown with rusty staining in places; slope 42.0
11. Mudstone, dark gray-green with purple to red-brown tints, silty; includes coarse angular black chert grains scattered throughout; slope 16.0
10. Mudstone, dark gray-green, silty, bentonitic; slope 22.0
9. Mudstone, pale green, silty; slope 5.0

8. Sandstone, gray, fine, thin-bedded to laminated; with yellow jarosite (?) stain; lenses out on one side and goes under slope cover on other; very resistant 2.5
7. Mudstone, dark gray, silty; slope 11.0
6. Mudstone, pale green, silty; slope 9.0
5. Siltstone, similar to unit 3, slope 37.0
4. Sandstone, gray, fine, soft, calcareous; exposed in gulleys in slope 4.0
3. Siltstone, pale green-gray, and red brown, soft calcareous; includes thin-bedded sandstone lenses; slope 68.0
2. Sandstone, similar to unit 1, but includes some low-angle cross-bedding and glauconite is absent; forms prominent ledge 4.0
1. Sandstone, gray, fine to medium, moderately cemented, calcareous; thin-bedded in lower part and thick-bedded in upper; includes some glauconite, and angular black chert grains; forms bare slope; contains lenses up to 1-foot-long of sandstone like unit 2 in upper part 7.0

Total Morrison and Cloverly 240.0

DISCONFORMITY

Sundance formation: (in part)
Sandstone, gray, moderately cemented, glauconitic

SECTION 6: PASS CREEK

Section measured on north side of, and about 0.25 mile from, Pass Creek, and about 2 miles east-northeast of Condit Ranch. Section begins in Sundance formation in NW 1/4 sec. 24, T. 44 N., R. 83 W., Johnson County, Wyoming. This is approximate location or slightly southeast of the Love, et al. (1945) South Mayoworth section. Measured with Brunton and tape. Strike: N 35° W; dip: 12° N 55° E.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part)
34. Shale, black
Rusty Beds member: 106 feet thick
33. Sandstone, tan, very fine to fine, shaly, laminated and very small-scale cross-bedded; with minor black shale as partings in lower part; uppermost 2 feet is heavily stained with red-brown and rusty coating, and forms ledge 16.0
32. Shale and siltstone, similar to unit 19 and the lower part of unit 20 at section 1; with coarse sandstone up to several inches thick in lowermost foot; with much rusty and some yellow ferruginous staining 90.0

UNCONFORMITY

Cloverly formation: 68 feet thick
Mudstone member: 46 feet thick
31. Sandstone, white, fine to coarse and conglomeratic, cross-bedded; unit thins southward and becomes parallel-bedded, and either thins out or "shales out" about a mile from the section, where it is a prominent ledge; polished pebbles in place at top 20.0
30. Siltstone to very fine sandstone, gray; rubble-covered slope; unit thins southward; 26.0

Otter Creek sandstone member: 22 feet thick
29. Sandstone, white, fine to coarse, conglomeratic lower 6 feet with chert and quartzite, cross-bedded with dips generally inclined eastward; prominent ledge; thins southward but still is cross-bedded and a ledge-former; northward, units 29, 30, and 31 all thin and become indistinct in grass-covered rolling hills; sparkly; with ferruginous staining locally; irregular bottom surface, and variable thickness 22.0

DISCONFORMITY

UPPER JURASSIC
Morrison formation: 232 feet thick

28. Covered slope with dark gray-green mudstone in lower part, and drab green mudstone in upper 42.0
27. Siltstone, gray, silicified; includes rounded quartz grains; highly fractured; ledge 3.0
26. Mudstone, dark gray-green, bentonitic (?); with rusty staining; slope 21.0
25. Mudstone, dark red-brown, calcareous; with rusty stain; slope 13.0
24. Mudstone, olive-green, silty, calcareous; mostly covered slope 22.0
23. Sandstone, gray, fine, well cemented, calcareous; irregularly thin-bedded to laminated; includes ferruginous nodules 0.5
22. Mudstone, olive-green, silty, calcareous; slope 2.0
21. Sandstone, gray, fine to medium, moderately cemented, calcareous, cross-bedded; includes pale green siltstone slivers and fragments, and randomly distributed ferruginous nodules; with large rusty spots; forms short ledge 6.0
20. Siltstone, green, calcareous; slope 33.0
19. Sandstone, gray, fine, moderately cemented, calcareous, cross-laminated in sets 1 to 3 feet thick ; contains thin interbeds of tan, fine, less well cemented sandstone; sparkly; includes ferruginous nodules and limonite specks; much slumping 22.0
18. Siltstone, green, calcareous; slope 11.0
17. Sandstone, gray, fine to medium, well cemented, calcareous; in thin lenticular beds averaging 1-foot-thick separated by pale green siltstone; conglomeratic; with rusty spots and patches; includes bone fragments; ledge 3.0
16. Siltstone, green and red-brown, calcareous; slope 23.0
15. Sandstone, similar to unit 11 ..... 1.0
14. Siltstone, dark gray-green, calcareous; slope 3.0
13. Sandstone, gray, fine, well cemented, calcareous; includes some very small-scale cross-bedded units; sparkly; prominent ledge 6.0
12. Siltstone, dark gray-green, calcareous; slope 4.0
11. Sandstone, gray, fine, calcareous; sparkly; forms small short ledge 0.5
10. Siltstone, drab green-gray, calcareous; slope 7.0
9. Limestone, gray, sandy; ledge 1.0
8. Mudstone, chocolate red-brown, calcareous; slope 8.0

Total Morrison and Cloverly 300.0

DISCONFORMITY

Sundance formation: (in part)

7. Sandstone, pepper and salt appearance, very fine to medium, moderately cemented, calcareous, very small-scale cross-bedded; prominent ledge 8.0
6. Siltstone, dark gray, shaly, slightly calcareous; rusty staining in places; weathers pale blue-green; slope 37.0
5. Sandstone, gray to tan, fine, calcareous; glauconitic; slope 4.0
4. Sandstone, gray, very fine, very calcareous; includes fine to medium glauconite grains; ledge 1.0
3. Sandstone, dark gray, very fine, calcareous; includes scattered black glauconite (?) grains; slope 15.0
2. Siltstone to very fine sandstone, drab green, calcareous; slope 15.0
1. Siltstone to very fine sandstone, dark gray, calcareous, slope 20.0

SECTION 7: NORTHWEST CLARK RANCH

Section measured about 2.5 miles northwest of Clark Ranch, and about 1.2 miles N5°W of measured section 5. Section begins in Sundance formation in S 1/2 SW 1/4 sec. 11, T. 43 N., R. 83 W., Johnson County, Wyoming. Measured with Brunton and tape. Strike: N-S; dip: 10° E.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

21. Shale, black

Rusty Beds member: 107 feet thick

20. Sandstone, similar to unit 19 at section 5, but gray 11.0
19. Siltstone, drab green, shaly, laminated, and inter-laminated

black shale; some minute cross-laminations; rusty and yellow ferruginous staining along bedding surfaces; slope 17.0

18. Shale and siltstone, similar to unit 32 at section 6 (that is, typical Rusty Beds); slope 79.0

UNCONFORMITY

Cloverly formation: 29 feet thick
Otter Creek sandstone member

17. Sandstone, white, medium to coarse, with conglomeratic zones, moderately cemented, cross-bedded; includes white chert and clay balls; ferruginous nodules randomly distributed; tan, yellow, and rusty ferruginous stains locally; cross-bed readings from sets averaging 1-foot-thick are inclined 22° toward N 55° E, 18° toward N75°E, 30° toward S80°E, and from a 3-foot-thick set at top, 30° toward N85°E; forms prominent ledge 29.0

DISCONFORMITY

UPPER JURASSIC
Morrison formation: 228 feet thick

16. Mudstone, gray, silty; with zones of coarse sandstone; rusty staining locally; slope 1.0
15. Mudstone, dark gray to drab gray-green, bentonitic; slope 42.0
14. Mudstone, dark gray, silty; with rusty stain; slope 26.0
13. Mudstone, green-gray, silty, bentonitic; slope 13.0
12. Mudstone, drab green-gray, silty, calcareous; slope 32.0
11. Limestone, gray, hard; lenticular; resistant 0.5
10. Mudstone, gray-green, silty, calcareous; slope 10.0
9. Sandstone, white, fine, moderately cemented, calcareous; sparkly because of inclusion of large crystals of calcite which enclose sand grains, sugary; blocky weathering ledge, with variable thickness; tapers in both directions 3.0
8. Sandstone, gray-green, fine to very fine, poorly cemented, slightly calcareous; slope 9.0
7. Siltstone, gray-green, calcareous; slope 37.0
6. Sandstone, gray, fine to medium, poorly cemented; massive; bleached; slope 13.0
5. Siltstone, dark gray-green; slope 16.0
4. Sandstone, gray, fine, moderately cemented, calcareous, laminated and possibly very low-angle cross-bedded; sparkly; slope 6.0
3. Mudstone, red-brown with green, calcareous; slope 8.0
2. Siltstone, pale green, hard, calcareous; thin ledge 0.5
1. Siltstone, red-brown with green, calcareous; slope 11.0

Total Morrison and Cloverly 257.0

DISCONFORMITY

Sundance formation (in part)
Sandstone, gray, very fine; includes gray mudstone fragments; weathers brown; prominent ledge

SECTION 8: NORTHEAST ARMINTO

Section measured about 0.6 mile east of Buffalo Creek Road, and 5.7 miles N24°E of Arminto. Section begins in Sundance formation on hogback west of log cabin in NE 1/4 NW1/4 sec. 19, T. 38 N., R. 86 W., Natrona County, Wyoming. This is approximate location of Arminto section of Love et al. (1945) and Woodward (1957). Measured with Brunton and tape. Strike: N 85° W; dip: 40° S 5° W.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part)
Rusty Beds member: incomplete, 71 feet thick

19. Shale, black, paper-thin, and siltstone, to fine sandstone, gray to brown, similar to lower part of unit 20 at section 1; 1-to 2-foot-thick moderately resistant shaly sandstone with heavy red-brown stain

which "caps" Rusty Beds member at sections 1 to 7 is not apparent here 34.0

18. Slope with soil and rubble cover, probably similar to unit 19 at section 1 ..... 37.0

UNCONFORMITY

Cloverly formation: 67 feet thick

Mudstone member: 32 feet thick

17. Sandstone, similar to unit 15, but blocky, and includes polished pebbles in place and coarse quartz grains; ledge 4.0
16. Sandstone, similar to unit 15, but heavily impregnated with rust; slope 10.0
15. Sandstone, white to gray, fine, moderately cemented; slightly sparkly; with red-brown spots, streaks, and zones, and very heavy rusty staining along fractures; hard; covered slope 5.0
14. Siltstone, pale green and red-brown; covered slope 13.0

Otter Creek sandstone member: 35 feet thick

13. Sandstone, gray, very fine to fine, moderately cemented, small-scale low-angle cross-bedded; with ferruginous staining along bedding; polished pebbles as float on slope; lower part under rubble cover; upper part a prominent ledge 35.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 182 feet thick

12. Mudstone, pale green, bentonitic; with upper 10 feet black to dark gray, and non-bentonitic; slope 22.0
11. Mudstone, olive-green; slope 6.0
10. Siltstone, dark gray to green-gray, silty; includes calcified nodules locally; with rusty staining along fractures; slope 11.0
9. Mudstone, black; soil-covered slope 7.0
8. Siltstone, similar to unit 6, but green and brown 25.0
7. Limestone, similar to unit 5 ..... 0.3
6. Siltstone, light olive-green with red-brown specks and zones; soft; slope 5.0
5. Limestone, gray, finely crystalline; weathers nodular; may be considered calcified mudstone; resistant 1.0
4. Mudstone, red-brown and pale green, silty, calcareous; slope 8.0
3. Sandstone, gray to white, fine, well cemented, slightly calcareous; sparkly; includes ferruginous nodules up to 9 inches long, and limonite specks throughout; bottom surface irregular and channeled into unit 2; variable thickness; forms upper part of hogback that includes units 2 and 3 ..... 8.0
2. Sandstone, white, fine, moderately cemented, calcareous, thick-to very thick-bedded; main part of hogback 38.0
1. Slope with soil and rubble cover; includes fragments of mudstone, olive-green; siltstone, pale olive-green, poorly cemented; sandstone, gray, fine, moderately cemented, sparkly; and some mudstone, red-brown; all fragments are calcareous 51.0

Total Morrison and Cloverly 249.0

DISCONFORMITY

	Feet
Sundance formation: (in part) Limestone, gray, coarsely crystalline, sandy; with many shell fragments; forms hogback	5.0

SECTION 9: NORTH ARMINTO

Section measured about 2.2 miles west of Buffalo Creek Road, and 6.5 miles N4°W of Arminto. Section begins in Sundance formation in S 1/2 SE 1/4 sec. 10, T. 38 N., R. 87 W., Natrona County, Wyoming. Measured with Brunton and tape. Strike: N 60° W; dip: 10° S 30° W.

LOWER CRETACEOUS — Feet

Thermopolis shale: (in part)

Rusty Beds member: (in part)

20. Shale, siltstone, and very fine sandstone, similar to unit 19 at section 1; covered with soil and rubble ..... 25.0+

UNCONFORMITY

Cloverly formation: 31 feet thick

Otter Creek sandstone member

19. Sandstone, white, fine to coarse, moderately cemented, low-angle cross-bedded with dips inclined generally toward the east; locally conglomeratic with chert and quartzite; with light limonite staining; lower 15 feet obscured by soil and talus blocks, but assigned to unit 19 on basis of slope profile; upper part forms a prominent ledge; thickness variable 31.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 186 feet thick

18. Siltstone, dark gray to black, bentonitic (?), soft; with rusty staining; slope 23.0
17. Slope, similar to unit 16, but with pale green to dark gray mudstone fragments; silicified wood and selenite fragments occur as float on slope and in soil 22.0
16. Slope, covered by soil and rubble; pale green silty mudstone fragments in soil 15.0
15. Siltstone, dark gray-green, soft; slope 3.0
14. Mudstone, purplish red-brown with light green, soft, calcareous; slope 11.0
13. Sandstone, olive-green, very fine, soft; slope 3.0
12. Sandstone, gray to pale yellow, fine to medium, moderately cemented, very thin-bedded with lower half parallel-bedded and the upper half cross-bedded in sets about 1 foot thick; cross-bed orientation is indeterminate because of small scale and much slump; sparkly; basal contact only slightly irregular; prominent ledge 12.0
11. Siltstone, dark gray-green, soft, calcareous; slope 10.0
10. Mudstone, similar to unit 9, but hard and forms ledge; lenticular; maximum 4.0
9. Mudstone, gray-green, silty, soft, calcareous; locally is tinted pale purple; slope 9.0
8. Siltstone, pale green, well cemented, calcareous; nodular and lenticular, thinning and shaling out in both directions within 100 feet; short ledge 2.0
7. Siltstone, pale green and purple; very slightly calcareous; soft; slope 5.0
6. Sandstone, gray to white, very fine, well cemented, calcareous, thick-bedded (averaging 6 inches); sparkly; thins out northeast-ward within about 100 feet and goes under rubble slope southwest-ward; ledge 6.0
5. Siltstone, chocolate red-brown with minor pale green zones, calcareous; purple from 17 to 18 feet above base; uppermost 2 feet is pale green; slope 20.0
4. Sandstone, pale gray-green, fine, poorly cemented, calcareous; slope 4.0
3. Sandstone, red-brown with pale green, fine, calcareous; slope 26.0
2. Sandstone, pale green with red-brown, fine, calcareous; slope 3.0
1. Sandstone, pale green, fine, calcareous; slope 8.0

Total Morrison and Cloverly 217.0

DISCONFORMITY

Sundance formation: (in part)

Sandstone, gray, fine, moderately cemented, calcareous; sparkly;

ledge 10.0
Limestone, gray, crystalline; with shell fragments; prominent
ledge 4.0

SECTION 10: BAKER CABIN ROAD

Section measured on prominent slope on east side of dry wash which is parallel to and on east side of Baker Cabin Road, about 3 road miles southeastward (2.2 miles straight line distance S60°E) from junction with Buffalo Creek Road. Section begins in Sundance formation in E 1/2 NW 1/4 sec. 25, and continues southeastward into W 1/2 NE 1/4 sec. 25; offset begins in Otter Creek sandstone member of Cloverly formation about 0.5 mile south-southeastward where the Baker Cabin Road cuts through the Otter Creek sandstone and about 200 feet west of where the road crosses the dry wash, in SE 1/4 sec. 25, T. 39 N., R. 86 W., Natrona County, Wyoming. Measured with Brunton and tape. Strike: N 45° E; dip: 10° S 45° E.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part)
Rusty Beds member: 78 feet thick
24. Shale, siltstone, and very fine sandstone, similar to unit 19 at section 1 ..... 78.0

UNCONFORMITY

Cloverly formation: 56 feet thick
Mudstone member: 19 feet thick
23. Sandstone, gray, fine, moderately cemented, calcareous in places, grades upwards to very fine; includes medium to coarse grains scattered throughout; upper 1 to 3 inches is conglomeratic with heavy ferruginous stain and includes polished pebbles in place; blocky; ledge, best exposed in roadcut 11.0
22. Sandstone, gray, fine, massive; includes ferruginous nodules, and heavy rusty staining on fractures and weathered surfaces and as impregnations; sparkly; less prominent ledge than unit 23 ..... 2.0
21. Mudstone, pale green with red and purple, silty; includes some fine sandstone layers; ferruginous staining locally; slope 6.0

Otter Creek sandstone member: 37 feet thick
20. Sandstone, white, medium to coarse, moderately cemented, with cross-bedding inclined 18° toward N70°E at top at main section, whereas at offset dips are lower; locally conglomeratic with chert; locally rusty staining along bedding surfaces; prominent ridge at main section, and bottom of offset; variable thickness 37.0

DISCONFORMITY

UPPER JURASSIC
Morrison formation: 242 feet thick
19. Slope, soil, brush, and rubble cover; probably siltstone or silty mudstone 48.0
18. Sandstone, white, fine, well cemented; includes ferruginous nodules, and heavy rusty staining along fractures and as impregnations; sparkly, blocky; ledge 14.0
17. Slope with heavy soil and rubble cover; pale green, silty, bentonitic (?) mudstone fragments in soil 13.0
16. Mudstone, dark gray, silty, soft; slope on which silicified wood occurs as float 21.0
15. Sandstone, gray, medium, poorly cemented, slightly calcareous; coarse grains scattered throughout; includes ferruginous nodules; sparkly; bedding poorly defined; slope 2.0
14. Mudstone, light green, silty, soft; slope 26.0
13. Siltstone, light green and red-brown, calcareous, soft, with 3-inch-thick hard gray limestone at base; slope 16.0
12. Mudstone, gray-green, with red-brown in lower part; slope 5.0
11. Mudstone, gray, silty, calcareous, hard; forms rounded blocky ledge; lenticular 2.0

10. Mudstone, gray-green, silty, calcareous, soft; slope..... 8.0
9. Limestone, gray, silty, hard; forms rounded blocky ledge 1.0
8. Mudstone, dark gray-green, soft; slope 2.0
7. Limestone, gray, silty, dolomitic (?), hard; forms massive ledge; includes calcite seams; units 7, 9, and 11 appear to thin out within 100 feet northwestward along rim, but continue southeastward..... 2.0
6. Mudstone, gray, silty, slightly calcareous; slope 8.0
5. Mudstone, red-brown, calcareous, soft; slope 6.0
4. Siltstone, gray, slightly calcareous, hard; sparkly; forms rounded blocky ledge; lenticular 1.0
3. Mudstone, red-brown with pale green, calcareous; slope 5.0
2. Sandstone, white to gray, very fine, well cemented; very sparkly; channeled up to several inches into unit 1; forms massive ledge..... 1.0
1. Sandstone, white, fine to medium, moderately cemented, calcareous, cross-bedded; sparkly; includes ferruginous nodules locally at offset; at main section, about middle of unit, a 10-foot-thick cross-bed set is inclined 19° toward N45°E; in upper part of unit at offset, cross-bed dips are inclined 17° toward N52°E in a 12-foot-thick set, with its top truncated by another set which dips 18° toward S40°W; nearby, 2 other adjacent sets are inclined respectively 12° toward S30°W and 5° (?) toward N40°W; also, a 20-foot-thick set dips 31° toward S40°E; a crescentic-shaped cross-bed set dips 18° northward, westward, and southward along an arc, and appears to be a preserved dune that measures about 65 feet from wing to wing; the whole unit appears to be an eolian deposit..... 61.0

Total Morrison and Cloverly 298.0

DISCONFORMITY

Sundance formation: (in part)
Limestone, gray, sandy, oolitic, cross-bedded; forms ledge; base under cover 3.0

SECTION 11: ALKALI CREEK

Section measured on slope on east side of Alkali Creek about 0.4 mile north of Thirtythree Mile Road, 2 miles southward from the junction of Alkali and Willow Creeks, and 24.4 miles due north of Natrona, Wyoming. Section begins in Sundance formation in NE 1/4 NE 1/4 sec. 4, and continues eastward up slope; offset begins in Otter Creek sandstone member of Cloverly formation where the Thirtythree Mile Road crosses this member, in NE 1/4 SE 1/4 sec. 4, T. 39 N., R. 83 W., Natrona County, Wyoming. Measured with Brunton and tape. Strike: N 40° E; dip: 6° S 50° E.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part)
32. Shale, black
Rusty Beds member: 98 feet thick
31. Siltstone, gray and tan, shaly with interlaminated black shale; with limonite staining, and uppermost foot with heavy rusty and red-brown staining and impregnations; has slaty ring; ledge 19.0
30. Shale and siltstone, similar to bulk of Rusty Beds member at other sections; contact irregular and undulating; slope..... 79.0

UNCONFORMITY

Cloverly formation: 69 feet thick
Otter Creek sandstone member
29. Sandstone, gray, medium to coarse, very conglomeratic throughout, moderately cemented, with cross-bedding in sets averaging 1 foot thick and inclined 31° toward the east (in set 7 feet above base of unit); sparkly; includes ferruginous nodules, and rusty, brown, tan, and green staining, pebbles include quartzite and green mudstone pellets; a few polished pebbles occur as float at both the main section and at the offset, and one is in place on top surface at the offset; prominent ledge 42.0

28. Siltstone, red-brown, shaly; slope; this unit may represent a tongue of the Mudstone member 21.0
27. Sandstone, gray, medium to coarse, conglomeratic with silicified wood fragments and gray siltstone fragments; appears to grade upward into siltstone similar to unit 28, but weathers blue-green and includes coarse grains scattered throughout and heavy yellow (jarosite ?) staining, and coalified wood fragments; channeled into unit 26; lower part is ledge 6.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 197 feet thick

26. Sandstone, blue-gray, very fine; includes egg-size ferruginous nodules, and rusty and yellow staining 1.0
25. Mudstone, dark gray to black, silty; soft; rusty staining on fractures, and yellow staining prominent in upper 5 feet; slope 25.0
24. Limestone, gray, lithographic, hard; massive ledge with no lateral extent apparent 1.0
23. Siltstone, dark gray to black, with some pale green silty mudstone in middle part; soft; bone fragments occur as float on slope 27.0
22. Mudstone, bright olive-green, soft; slope 12.0
21. Sandstone, gray, very fine, calcareous, with poorly defined cross-bedding; includes ferruginous nodules up to 1 foot long; basal foot is conglomerate containing coalified wood fragments, and channeled into unit 20; includes medium black chert grains; sparkly because of inclusion of large crystals of calcite which enclose sand grains; ledge; variable thickness 4.0
20. Siltstone, dark gray-green, with red-brown on fractures, calcareous; purplish at 10 feet above base; includes coarse grains scattered throughout; slope 28.0
19. Mudstone, red-brown and light green, becoming brown at 5 feet, and gray at 9 feet; bentonitic; slope 11.0
18. Mudstone, dark gray-green, silty, calcareous; slope 3.0
17. Limestone, or calcified siltstone with calcite crystals; gray; includes ferruginous nodules; ledge 1.0
16. Mudstone, olive-green, silty in lower part, slightly bentonitic; with minor red-brown along fractures in lower part; slope 13.0
15. Sandstone, pale red-brown, very fine, well cemented, calcareous, massive; lenticular; ledge 1.0
14. Mudstone, red-brown and pale green; becomes silty in upper two-thirds; slope 28.0
13. Siltstone, red-brown, calcareous; slope 5.0
12. Mudstone, dark gray-green, calcareous; slope 6.5
11. Sandstone, gray, fine, well cemented; ledge 0.5
10. Sandstone, gray-green with red-brown along bedding surfaces, fine, calcareous, very thin-bedded; soft; slope 6.0
9. Sandstone, gray, very fine, calcareous, very thin-bedded to laminated, well cemented; ledge 1.0
8. Sandstone, gray-green, fine, soft, calcareous; slope 3.0
7. Mudstone, olive-green, calcareous, soft; includes gray, fine sandstone 3 inches thick at top; slope 2.0
6. Sandstone, gray, very fine, well cemented, calcareous; includes black chert grains; lenticular; ledge 0.5
5. Mudstone, red-brown, calcareous, soft; slope 4.0
4. Sandstone, gray, very fine, moderately cemented, calcareous, massive; lenticular; ledge 2.0
3. Sandstone, similar to unit 1 ..... 5.0
2. Sandstone, gray, very fine, moderately cemented, calcareous, shaly; ledge 0.5
1. Sandstone, gray-green, very fine, calcareous, soft shaly; slope 6.0

Total Morrison and Cloverly 266.0

DISCONFORMITY

Sundance formation: (in part)
Sandstone, gray, glauconitic, low-angle cross-bedded, and limestone, gray, with many shell fragments

SECTION 12: SPRING CREEK

Section measured on prominent rim projection about 0.5 mile N. 10° E. from where road crosses Spring Creek over a culvert, and about 7.5 miles S. 40° E. of Tensleep, Wyoming. Section begins in Sundance formation in NW 1/4 sec. 20, and continues westward up slope into NE 1/4 sec. 19; offset begins in upper part of Otter Creek sandstone member of Cloverly formation about 0.4 mile downdip in NE 1/4 sec. 19, T. 46 N., R. 87 W., Washakie County, Wyoming. Measured with Brunton and tape. Strike: N 5° W ; dip: 7° S 85° W.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part)
Rusty Beds member: (in part)
20. Shale and siltstone to very fine sandstone, similar to unit 20 and upper part of unit 19 at section 1 ..... 75.0
19. Shale, black, and siltstone, pale green and drab, similar to lower part of unit 19 at section 1 ..... 7.0
18. Concretionary layer, similar to units 15 and 17 at section 5; less than 3 inches thick

UNCONFORMITY

Cloverly formation: 132 feet thick
Mudstone member: 40 feet thick
17. Sandstone, light red-brown, fine to medium; includes coalified wood fragments; sparkly; soft; slope 5.0
16. Sandstone, gray, fine to coarse, massive; includes chert and ferruginous nodules; with rusty staining; measured at offset; thins out before main section 3.0
15. Siltstone, red-brown and olive-green, with rusty staining; slope 5.5
14. Sandstone, gray, fine to medium, moderately cemented; includes large fragments of coalified wood; with heavy rusty staining and impregnations; ledge 0.5
13. Siltstone, red-brown, with interlaminated shale, black; both rock types include coalified wood fragments; with minor rusty staining; slope.....4.0
12. Sandstone, gray, coarse, with 2-foot-thick cross-bedded set inclined 32° toward S 40° W; with heavy limonite staining; dip slope; at offset, ripples 2 feet above base strike N 17° E., and ripples 5 feet above base strike N 5° W 8.0
11. Slope, with soil and tree cover; fragments in soil include siltstone, very fine sandstone, and some black shale; coalified wood fragments are present in any rock type 14.0

Otter Creek sandstone member: 92 feet thick
10. Sandstone, white to gray, fine to coarse, cross-bedded, moderately to well cemented; lower 10 feet conglomeratic; sparkly, sugary; locally includes ferruginous nodules, and tan and rusty staining; weathers into lower cliff 30 feet high, lower slope 7 feet, middle cliff 20 feet, upper slope 13 feet, and upper cliff 22 feet; bottom channeled into unit 9; in lower cliff, a 2-foot-thick cross-bed set has dips inclined 30° toward N 60° W., and in a 3-foot-thick set, 10° toward N 60° W ; at base of upper cliff, a 3- foot-thick cross-bed set has dips inclined 13° toward the north 92.0

DISCONFORMITY

UPPER JURASSIC
Morrison formation: 251 feet thick
9. Mudstone, dark gray to black, silty, shaly; slope 12.0

8. Slope with soil, tree, and rubble cover; dark gray-green silty mudstone fragments in soil 21.0
7. Mudstone, dark gray-green, silty, soft; includes bone layer at 8 feet above base; slope 25.0
6. Sandstone, olive-green and brown, fine, poorly cemented; slope 11.0
5. Sandstone, gray, fine, poorly cemented; includes black chert grains; with ferruginous staining; sparkly 1.0
4. Sandstone, drab green, very fine, poorly cemented; sparkly; slope 3.0
3. Sandstone, gray, medium to fine, moderately cemented, massive; includes pale green clay galls; sparkly; continues to offset with variable thickness; forms a poor ledge 4.0
2. Siltstone, olive-green with red-brown, calcareous; slope 121.0
1. Mudstone, olive-green, silty, calcareous; exposed as fragments in soil of slope with rubble and tree cover; appears to grade into red-brown silty mudstone and siltstone in upper half 53.0

Total Morrison and Cloverly 383.0

DISCONFORMITY

Sundance formation: (in part)
Sandstone, green to gray, fine, poorly to moderately cemented, thin-bedded, glauconitic; slope 8.0
Limestone, gray, very sandy, shelly, glauconitic; ledge 4.0
Sandstone, green, poorly cemented, glauconitic, cross-bedded; slope 12.0

SECTION 13: OTTER CREEK

Section measured on rim projection on north side of Otter Creek about 0.4 mile north of Woosley Ranch, and 11.5 miles S 27°E of Tensleep, Wyoming. Section begins in Sundance formation, which is exposed in gulleys on both sides of a dirt road extending northward from ranch house, in NW 1/4 sec. 8, and continues westward into NE 1/4 sec. 7: offset begins at base of Mudstone member of Cloverly formation several hundred feet down dip, still in NE 1/4 sec. 7, T. 45 N., R. 87 W., Washakie County, Wyoming. The 1/4 corner between secs. 7 and 8 lies a few hundred feet east of the main house at Woosley Ranch. Measured with Brunton and tape. This is type section of the Otter Creek sandstone member of the Cloverly formation. Strike: N 10° E; dip: 5° N 80° W.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

Rusty Beds member: (in part)

14. Shale, siltstone, and very fine sandstone, similar to units 19 and 20 at section 1, that is, typical Rusty Beds member

UNCONFORMITY

Cloverly formation: 106 feet thick

Mudstone member: 44 feet thick

13. Sandstone, gray, fine to medium, moderately cemented, thin-bedded and small-scale cross-bedded (sets less than 6 inches thick); sparkly; with brown and red ferruginous staining; blocky ledge; at one place, cross-bedding inclined 33° toward S 55° W; unit thins toward offset to 7 feet thick, and appears to split so that lower part has thin tongue extending into unit 12; thickness at main section 16.0
12. Siltstone to silty mudstone, gray with red tint; with sandstone, gray, fine, sparkly, and mudstone, pale gray-green, interbedded; with rusty and yellow ferruginous staining; polished pebbles occur as float in slope at main section 28.0

Otter Creek sandstone member: 62 feet thick

11. Sandstone, white to gray, fine to coarse, and conglomeratic, moderately to well cemented, cross-bedded with sets generally less than 1 foot thick; includes ferruginous nodules as much as 3 inches in long diameter, randomly distributed throughout unit; crops out as lower conglomeratic cliff with pebbles of chert and quartzite, 31 feet thick, a middle cross-bedded sandstone slope,

23 feet thick and an upper cliff similar to the lower but only 8 feet thick; cross-bedding in the lower cliff in inclined 22° toward N 60° W. at one place; polished pebbles occur as float on the lower cliff top surface; lower contact of unit is channeled into unit 10 and fragments of unit 10 are included in the basal foot of the conglomeratic sandstone; variable thickness along outcrop probably the result of irregularities of lower contact, at least in part; upper contact seems conformable 62.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 210 feet thick

10. Sandstone, gray, fine, well cemented, laminated; with limonite staining parallel to laminae, and red-brown ferruginous staining along fractures locally; in upper half, includes lenticular resistant sandstone layers 2 to 6 inches thick; gradational with unit 9; variable thickness; forms undercut at base of cliff-forming unit 11 ..... 5.0
9. Sandstone, dark gray-green and rusty-brown, fine to medium, soft; with carbonaceous mudstone partings; upper third of unit is dark gray siltstone; slope 17.0
8. Sandstone, pale red-brown, medium to coarse, poorly sorted, poorly cemented; with minor limonite and yellow ferruginous staining; includes coalified wood fragments; slope 15.0
7. Mudstone, gray-green, silty, soft; includes silicified wood fragments as float on slope 16.0
6. Sandstone, gray, fine to coarse, poorly cemented, cross-bedded; includes white chert and some kaolinized (?) feldspar; sparkly; with limonite staining along bottom which has irregular basal contact; cross-bedding in 1-foot-thick set at base inclined 24° toward N 10° E; forms rounded ledge 12.0
5. Sandstone, dark gray-green and brown-green, very fine, poorly cemented, calcareous; becomes light gray in upper half; slope 60.0
4. Slope, with soil and grass cover; with light brown sandy soil; probably similar to units 3 and 5 ..... 58.0
3. Sandstone, dark gray-green, very fine, soft, calcareous; slope 10.0
2. Sandstone, white, fine, moderately cemented, thin-bedded to laminated, calcareous; poor ledge 1.0
1. Mudstone, red-brown and dark gray-green, silty, calcareous; soft; includes sandstone, gray, very fine, well cemented, calcareous, sparkly, resistant that occur as layers as much as 6 inches thick, and a basal 6-inch-thick sandstone; slope 16.0

Total Morrison and Cloverly 316.0

DISCONFORMITY

Sundance formation: (in part)

Limestone, gray, sandy, shelly, glauconitic; ledge 4.0

SECTION 14: TENSLEEP

Section measured across hogbacks on north side of U.S. Highway 16 about 1.5 miles S 80° W., of Tensleep, Wyoming. Section begins in Sundance formation in SW 1/4 sec. 24, T. 47 N., R. 89 W., Washakie County, Wyoming. Measured with tape. This is approximate location of Darton's (1906) Tensleep section of Cloverly formation. Strike: N 60° W; dip: 62° S 30° W.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

Rusty Beds member: (in part)

19. Shale, siltstone, and minor very fine sandstone, similar to units 19 and 20 at section 1, that is, typical Rusty Beds member

UNCONFORMITY

Cloverly formation: 123 feet thick

Mudstone member: 61 feet thick

18. Sandstone, white, fine, moderately cemented, thin-bedded and

very low-angle cross-bedded; sparkly; uppermost several inches contains very coarse sand grains and small pebbles; upper surface undulating and includes ripples; with rusty, pink, and brown ferruginous staining; hogback with variable resistance and thickness; maximum thickness 10.0

17. Sandstone, gray, fine, moderately cemented, with some layers being very well cemented, resistant, sparkly, and containing carbonaceous material and rusty staining; and interbeds of mudstone, dark gray to black, silty, shaly, with coalified wood fragments; three polished pebbles as float; approximate thickness 30.0
16. Mudstone, gray-green with red-brown, silty; slope with soil cover 21.0

Otter Creek sandstone member: 62 feet thick

15. Sandstone, white to gray, fine, well cemented, lower 5 feet is thick-bedded whereas remainder of unit is cross-bedded; includes white chert grains and ferruginous nodules; includes conglomerate lens and is conglomeratic in places in lower half, but laterally the equivalent part of the unit becomes all sandstone; prominent ledge 62.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 236 feet thick

14. Siltstone, dark olive-green, well cemented, massive 3.0
13. Sandstone, gray, very fine, well cemented; sparkly; includes ferruginous nodules; bottom surface irregular; lower part of hogback 2.0
12. Mudstone, dark gray, soft; splits into shaly fragments; slope 10.0
11. Mudstone, black, lignitic (?), soft; slope with soil 9.0
10. Sandstone, gray-green, very fine, bentonitic; with selenite crystals as float; slope 36.0
9. Sandstone, gray-green, fine, poorly cemented; slope 14.0
8. Sandstone, gray, fine, moderately cemented, cross-bedded; includes ferruginous nodules; with pale green patches, zones, streaks very locally, and some limonite staining; sparkly; hogback with variable thickness as result of irregular lower surface 10.0
7. Mudstone, dark gray-green and red-brown, very silty, calcareous, soft; includes thin sandstone similar to unit 3, but as ferruginous-coated layers; slope 45.0
6. Sandstone, gray, medium, poorly cemented, calcareous; sparkly; locally splits into shaly fragments; slope 41.0
5. Sandstone, gray to tan, fine, well cemented, calcareous; sparkly; with small-scale low-angle cross-bedding; includes fragments of mudstone similar to unit 4; irregular lower surface; hogback with variable thickness 3.0
4. Mudstone, dark gray-green, calcareous, soft; slope 14.5
3. Sandstone, gray, very fine, well cemented, calcareous; includes minute coalified fragments; sparkly; ledge 0.5
2. Sandstone, dark gray-green, with red-brown, very fine, soft, calcareous; slope 21.0
1. Sandstone, dark gray-green, fine, soft, calcareous; lower contact appears conformable; slope 27.0

Total Morrison and Cloverly 359.0

DISCONFORMITY

Sundance formation: (in part)

Sandstone, gray, pepper-and-salt, moderately cemented, calcareous, glauconitic, thin-bedded; slope 10.0

Sandstone, similar to overlying one, but includes shells in lower part; slope 10.0

SECTION 15: NORTH BIG TRAILS

Section measured on prominent slope about 1 mile east of dirt road which passes Cogdill Ranch, about 5.2 miles N 13° W. of Big Trails, and about 14 miles S 24° E, of Tensleep, Wyoming. Section begins in Sundance formation in SE 1/4 sec. 20, and continues westward up slope; first offset begins at top of unit 15 in Morrison formation about 500 feet down dip and across narrow valley which dissects unit 15 dip slope, and continues westward into SW 1/4 sec. 20; second offset begins at top of Cloverly formation about 1500 feet farther down dip and about 800 feet east of dirt road, in SE 1/4 sec. 19, T. 45 N., R. 87 W., Washakie, County, Wyoming. Measured with Brunton and tape. Strike: N 5° W; dip: 7° S 85° W.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

Rusty Beds member: (in part)

27. Shale, siltstone, and very minor very fine sandstone, similar to units 19 and 20 at section 1, that is, typical Rusty Beds member

UNCONFORMITY

Cloverly formation: 48 feet thick

Mudstone member: 23 feet thick

26. Sandstone, gray, fine, moderately to well cemented, locally calcareous, thin-bedded; sparkly; with rusty, brown, tan, and yellow ferruginous staining; lower contact appears to be gradational with and to inter-tongue with unit 25 on small scale; includes coalified wood fragments; thins down dip; ledge 4.0
25. Sandstone, white to gray, very fine, soft; with rusty and lavender staining; a single polished pebble occurs as float on lower slope of unit; slope 19.0

Otter Creek sandstone member: 25 feet thick

24. Sandstone, white to gray, fine to coarse, and conglomeratic, cross-bedded; includes ferruginous nodules and limonite staining; cross-bedding inclined generally east to southeastward, and 1-foot-thick set at base inclined 18° S 70° E; unit is more than 50% conglomeratic, with pebbles of chert and quartzite as much as 3 inches in long diameter but mostly about 0.5 inch: uppermost few inches is a fine sandstone with lavender staining; bottom surface undulates and thickness is variable; prominent ledge 25.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 265 feet thick

23. Mudstone, pale gray-green, silty, soft; becomes darker gray in upper half; slope 79.0
22. Sandstone, gray, very fine, soft; upper 4 feet bentonitic (?) slope 12.0
21. Mudstone, dark gray, silty, soft; bentonitic; slope 7.0
20. Sandstone, gray, very fine to coarse, moderately cemented, cross-bedded; sparkly; includes ferruginous nodules, and coalified wood fragments; includes fragments of green mudstone in lower part; crops out as lower ledge 11 feet thick, middle slope 5 feet thick, and upper ledge 6 feet thick; at base, cross-bedding in 2-foot-thick set inclined 19° toward S 45° E; at 4 feet above base, dips in 1.5-foot set inclined 18° toward S 80° E; at 6 feet above base, dips in 3-foot set inclined 20° toward S 10° E; channeled into unit 19; variable thickness 22.0
19. Sandstone, dark gray to dark drab gray-green, very fine to fine, slightly calcareous, soft; slope 7.0
18. Sandstone, gray, soft, calcareous, very small-scale cross-bedded; sparkly; slope 6.0
17. Sandstone, gray-green, very fine to fine, soft, calcareous, very small-scale cross-bedded; slope 4.0
16. Sandstone, dark gray, very fine to fine, soft, slightly calcareous; slope; 7.0
15. Sandstone, tan, very fine to coarse, well cemented, calcareous, small-scale low-angle cross-bedded with dips inclined generally westward; sparkly; includes coalified wood fragments; crops out

as resistant ledges about 4 feet thick with interbedded coalified shaly sandstone layers as much as 2 feet thick, all variable in thickness; bottom channeled into unit 14; very locally conglomeratic; prominent ledge 21.0

14. Mudstone, gray in lower part, drab green in upper, silty to sandy, soft, calcareous; includes selenite veinlets in upper part; slope 4.0
13. Sandstone, white, fine to medium, poorly sorted, moderately cemented, thin-bedded, calcareous; appears to thin out about 200 feet down dip, under cover up dip; poor ledge 3.0
12. Sandstone, gray to olive-green, fine, calcareous, soft; includes medium grains scattered throughout; slope 5.0
11. Sandstone, gray, fine, soft, calcareous; becomes green upwards, and non-calcareous locally; slope 8.0
10. Sandstone, chocolate-brown to tan, fine, soft, calcareous; slope 4.0
9. Sandstone, tan, medium, soft, massive, calcareous; slope 2.0
8. Sandstone, gray, very fine to fine, soft, calcareous; appears massive; weathers pale green; slope 8.0
7. Siltstone, dark gray, weathers pale blue-green, massive, non-calcareous; grades upwards into very fine sandstone, and is calcareous in uppermost 2 feet; slope 17.0
6. Mudstone, red-brown with green, becomes silty upwards and finally becomes a siltstone, calcareous; slope 25.0
5. Mudstone, olive-green, soft, calcareous; slope 2.0
4. Sandstone, gray, soft, calcareous; slope 7.0
3. Mudstone, gray and green, very silty to siltstone, soft, calcareous; slope 6.0
2. Sandstone, similar to unit 1, but soft and much less glauconitic; slope 4.0
1. Sandstone, gray, very fine to fine, thin-bedded, calcareous; soft and slope-former except for well cemented uppermost 0.5 feet; includes minor fine to medium glauconite grains 5.0

Total Morrison and Cloverly 313.0

DISCONFORMITY: undulating contact

Sundance formation: (in part)

Sandstone, gray, medium, glauconitic, soft, calcareous 3.0
Sandstone, gray, medium to coarse, well cemented, calcareous, glauconitic, oolitic, shelly; laterally becomes sandy shelly limestone; ledge 4.0

SECTION 16: SOUTH BIG TRAILS

Section measured on prominent slope on west side of Nowood Creek, about 1.2 miles N 30° E, of Hampton Ranch via ranch road beginning at main house, about 7.8 miles S 20° W, of Big Trails, or about 25.8 miles S 10° E, of Tensleep, Wyoming; the section is also located about 1.6 miles N 13° W, of the 1/4 corner between sec. 31, T. 43 N., R. 87 W. and sec. 36, T. 43 N., R. 88 W. Section begins in Sundance formation in N 1/2 NW 1/4 sec. 25, T. 43 N. R. 88 W., Washakie County, Wyoming. Measured with Brunton and tape. Strike: N 35° E; dip: 7° N 55° W.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

Rusty Beds member: (in part)

25. Shale, siltstone, and minor very fine sandstone, similar to units 19 and 20 at section 1, that is, typical Rusty Beds member

UNCONFORMITY

Cloverly formation: 62 feet thick

Mudstone member: 32 feet thick

24. Sandstone, gray-green, very fine, thin-bedded to laminated, well cemented; includes ferruginous nodules locally, and coalified partings; ledge 7.0
23. Siltstone, tan, red-brown, and lavender, very fine sandstone locally, soft; with coalified fragments; mostly a covered slope 25.0

Otter Creek sandstone member: 30 feet thick

22. Sandstone, gray, medium to coarse, and conglomeratic, well cemented, low-angle cross-bedded; pebbles in lower conglomeratic part include chert and quartzite, as much as 1 inch in diameter but averaging 1/4 inch; locally sparkly; with tan, purple, rusty, and yellow ferruginous staining; unit thins northeastward for about 1000 feet and then becomes poorly exposed; thins to 21 feet in down dip direction; channeled into unit 21 below; prominent ledge 30.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 213 feet thick

21. Mudstone, dark gray, silty; similar in appearance to unit 19; uppermost foot heavily stained and impregnated with jarosite (?) slope 4.0
20. Mudstone, gray-green, silty locally; with red-brown in basal 3 feet, and dark gray in upper part; soft and slope-former except for some resistant layers as much as 5 inches thick; slope 38.0
19. Mudstone, similar to unit 17 but with rusty staining 4.5
18. Siltstone to very fine sandstone, gray, well cemented; highly weathered but forms thin ledge 0.5
17. Mudstone, dark gray, silty locally in lower part but becomes more silty and includes medium and coarse grains, and some pebbles upwards; soft; slope 62.0
16. Mudstone, red-brown, silty and sandy, calcareous, soft; slope 7.0
15. Slope with soil, grass, and tree cover 11.0
14. Sandstone, pale green to gray, fine, soft, calcareous; slope 10.0
13. Sandstone, red-brown and green, very fine to fine, soft; grades upwards into mudstone that is locally silty; includes 3 inch thick limestone similar to unit 10 at top; calcareous; slope 4.0
12. Mudstone, olive-green, silty, soft, calcareous; includes sandstone, gray, very fine, well cemented, calcareous, sparkly which occurs as 3 to 6-inch-thick ledge in middle of unit; slope 7.0
11. Mudstone, red-brown, soft, calcareous; slope 6.0
10. Limestone, gray, finely crystalline; ledge 0.5
9. Mudstone, dark gray, soft, calcareous; slope 1.0
8. Sandstone, gray, very fine to medium, moderately cemented, calcareous; includes fragments of green mudstone; sparkly; ledge 6.0
7. Sandstone, gray, very fine, soft, calcareous; includes green mudstone fragments in lower part; uppermost 2 feet is green and includes fine to medium grains; most of unit is slope, but interval from 16 to 21 feet above base forms rounded ledge 23.0
6. Mudstone, red-brown with pale green, silty, soft; locally a siltstone; slope 8.0
5. Sandstone, gray, fine, well cemented, calcareous; with medium to coarse grains scattered throughout; ledge 0.5
4. Mudstone, dark gray, soft, calcareous; slope 11.0
3. Sandstone, similar to unit 1 without coalified wood 4.0
2. Mudstone, olive-green, soft; slope 2.0
1. Sandstone, gray to white, very fine, moderately cemented, calcareous, very small-scale cross-bedded; sparkly; includes some coalified wood fragments; with silicified wood fragments occurring as float slope 3.0

Total Morrison and Cloverly 275.0

DISCONFORMITY: contact undulatory locally

Sundance formation: (in part)

Sandstone, gray-green, glauconitic, calcareous, shelly; includes limestone, gray, sandy, shelly, resistant occurring at the top as lenses as much as 1 foot thick 10.0

SECTION 17: NOWOOD

Section measured on slope on north side of Worland turnoff, about halfway, up hill from

Tensleep-Nowood road, and about 2 miles S 65° W, of Nowood. Section begins in Sundance formation in SE 1/4 sec. 19(?), T. 42 N., R. 88 W., Washakie County, Wyoming. Measured with Brunton and tape. Strike: E-W (?); dip: 14° northward.

	Feet
LOWER CRETACEOUS	
Thermopolis shale: (in part)	
Rusty Beds member: (in part)	
24. Shale and siltstone, similar to unit 19 at section 1, that is, typical lower part of Rusty Beds member	
UNCONFORMITY	
Cloverly formation: 124 feet thick	
Mudstone member: 47 feet thick	
23. Sandstone, white and non-calcareous, brown and calcareous, fine, cross-bedded; includes ferruginous nodules and polished pebbles occur as float on upper dip slope; sparkly; crops out as fractured knobs on ridge; cross-bedding; in 1-foot-thick set inclined 30° westward; minimum estimated thickness	16.0
22. Slope with soil and grass cover; with float from unit 23; probably siltstone	31.0
Otter Creek sandstone member: 77 feet thick	
21. Sandstone, white, fine to coarse, and locally conglomeratic, moderately cemented, cross-bedded; sparkly; includes white chert; crops out as low knobs on bench rimmed by unit 20; lower contact not exposed	77.0
DISCONFORMITY	
UPPER JURASSIC	
Morrison formation: 250 feet thick	
20. Sandstone, gray with lavender tint, very fine, well cemented, calcareous; fractured; sparkly; platy ring; ledge	2.0
19. Sandstone, olive-green, very fine to medium, soft; becomes dark gray upwards; upper third is rubble covered but included with unit; slope	47.0
18. Mudstone, dark gray to black, sparsely silty, soft; slope which weathers pale green	16.0
17. Mudstone, dark gray, silty, soft, calcareous; grades up from unit 16; slope	7.0
16. Mudstone, red-brown with green, soft, calcareous; slope	10.0
15. Siltstone, gray, soft, calcareous; slope	17.0
14. Mudstone, red-brown, soft, calcareous; slope	5.0
13. Sandstone, pale gray-green, very fine, soft, calcareous; slope	20.0
12. Sandstone, gray, medium, moderately cemented, calcareous, cross-bedded; sparkly; channel sandstone which thins out within 100 feet eastward and is under cover westward; includes sparsely scattered ferruginous nodules; much fracturing and slumping makes orientation of cross-bed dips unreliable; ledge	10.0
11. Sandstone, pale gray-green, very fine, soft, calcareous; includes coarse grains; slope	13.0
10. Sandstone, red-brown, fine to medium, moderately cemented, calcareous; with coarse grains throughout; slope	11.0
9. Slope, with sand and vegetation cover; forms bench	30.0
8. Sandstone, similar to unit 7, but soft; becomes red-brown and gray at 9 feet above base, gray-green at 13, pale red-brown at 23; slope up to bench (unit 9)	25.0
7. Sandstone, gray, fine to medium, well cemented, calcareous; includes scattered coarse grains; ledge	1.0
6. Sandstone, gray, medium, soft, calcareous, cross-laminated (?); slope	6.0
5. Mudstone, dark gray to red-brown, with olive-green, silty, soft, calcareous; slope	5.0
4. Sandstone, pale red-brown with some gray zones, very fine, soft, calcareous; slope	14.0
3. Mudstone, red-brown with minor olive-green, soft, calcareous; slope	3.0
2. Sandstone, gray, very fine, soft, calcareous, very small-scale cross-bedded; includes fragments of dark gray mudstone and coalified wood,	

and medium grains 3.0
1. Sandstone, white, very fine to medium, moderately cemented, calcareous, poorly-defined cross-bedding; with very minor glauconite; slope 5.0

Total Morrison and Cloverly 374.0

Feet

DISCONFORMITY

Sundance formation: (in part)
Sandstone, gray, very fine, shaly, glauconitic; slope 7.0
Sandstone, similar to underlying, but forms ledge 2.0
Sandstone, gray, calcareous, glauconitic, thin-bedded 20.0
Sandstone, gray, very calcareous, glauconitic; forms prominent ledge; grades laterally into limestone, gray, crystalline, sandy, shelly that also forms ledge 4.0

SECTION 18: MAYOWORTH

Section measured across Mayoworth-Gordon Ranch-Hat Ranch road at a locality 0.4 road-mile north of Condit mailbox, which is 1.2 miles westward from end of Kaycee-Mayoworth paved state road. Section begins in Sundance formation one cuesta west of road in NE 1/4 sec. 33, and continues eastward across road into NW 1/4 sec. 34, T. 45 N., R. 83 W., Johnson County, Wyoming. This is approximate location of North Mayoworth section of Love et al. (1945) and Mayoworth section of MacClintock (1957). Measured with Brunton and tape. Strike: N 47° W.; dip: 11° N 43° E.

Feet

LOWER CRETACEOUS
Thermopolis shale: (in part)
Rusty Beds member: (in part)
30. Shale and siltstone, similar to unit 19 at section 1, that is, typical Rusty Beds member

UNCONFORMITY

Cloverly formation: 59 feet thick
Mudstone member: 55 feet thick
29. Sandstone, grading upwards from very fine to coarse, and from dark gray to gray and red-brown to gray and tan; well cemented; prominent ledge 6.0
28. Coal, black, woody, shaly; becomes less coaly and more shaly upwards; with yellow ferruginous staining 4.0
27. Sandstone, gray, fine to coarse, well cemented; includes coalified wood slivers; quartzitic; variable thickness; ledge 1.0
26. Mudstone, olive-green becoming pale gray-green upwards; silty; slope 22.0
25. Mudstone, bright red-brown, silty locally, soft; slope 13.0
24. Mudstone, pale gray-green, locally silty, soft; slope 9.0

Otter Creek sandstone member: 4 feet thick
23. Sandstone, white, fine, moderately to well cemented, locally calcareous, cross-bedded; sparkly, sugary; includes ferruginous nodules; a few polished pebbles occur as float on dip slope of unit; bottom channeled into unit 22; ledge 4.0

DISCONFORMITY

UPPER JURASSIC
Morrison formation: 189 feet thick
22. Mudstone, dark gray to gray-green, silty, soft; upper 2 feet stained yellow-brown; slope 11.0
21. Siltstone, dark gray-green with red-brown tint, sandy, soft; slope 3.0
20. Mudstone, dark gray, sparsely silty, soft; slope 4.0
19. Mudstone, similar to unit 16, but black; poor ledge 3.0
18. Mudstone, gray-green, silty, soft; slope 3.0
17. Sandstone, gray, fine, soft; with yellow and rusty ferruginous

staining; slope 9.0

16. Mudstone, gray to brown, fine; includes analcite grains and coalified wood fragments; highly fractured; poor ledge 1.0
15. Mudstone, dark gray-green, silty, soft; slope 2.0
14. Siltstone, dark gray to black, carbonaceous; highly fractured; resistant ledge 1.0
13. Mudstone, similar to unit 11 ..... 14.0
12. Sandstone, gray-green, fine, soft; slope 3.0
11. Mudstone, dark gray to black, soft; slope 5.0
10. Mudstone, gray-green, locally silty, bentonitic; slope 17.0
9. Mudstone, olive-green, silty, soft, calcareous; slope 10.0
8. Sandstone, gray, very fine, moderately cemented, calcareous, very small-scale cross-bedded; includes sparsely scattered ferruginous nodules; with pale green coloration along bedding surfaces; variable thickness; ledge 5.0
7. Mudstone, olive-green to gray-green, with minor red-brown, silty, locally sandy, soft, calcareous; slope 21.0
6. Slope, with soil and grass cover, but probably similar to unit 7; includes road 37.0
5. Sandstone, gray, fine, soft, calcareous, low-angle cross-bedded; sparkly; slope 11.0
4. Sandstone, gray, fine, soft, calcareous, thin-bedded and small-scale cross-bedded; slope 5.0
3. Siltstone, dark gray-green, sandy, soft, calcareous; lenticular; slope 2.0
2. Sandstone, white, very fine to coarse, moderately cemented, calcareous, cross-bedded; includes ferruginous nodules, and fragments of green mudstone; sparkly; crops out as poor cap on ridge west of road; variable thickness 16.0
1. Sandstone, gray, shaly, calcareous; sparkly; includes 2-inch-thick finely crystalline limestone in middle; slope just below rim of cuesta 6.0

Total Morrison and Cloverly 248.0

DISCONFORMITY

Sundance formation: (in part)

Shale, dark gray, silty; includes thin gray, calcareous; glauconitic sandstone layers; slope 2.0
Siltstone, gray-green, calcareous, resistant; grades laterally into sandy limestone; ledge 1.0
Slope, covered with soil 2.0
Sandstone, green-gray, glauconitic, calcareous, small-scale cross-bedded; with rusty spots; ledge 4.0
Sandstone, gray, glauconitic; slope 5.0
Shale, dark gray, silty; slope 7.0

SECTION 19: WILLOW CREEK

Section measured on slope on west side of Willow Creek about 1 mile due west of main house on Firnekas Ranch, and about 29.6 miles N 3° E of Natrona, Wyoming. Section begins in Sundance formation in SE 1/4 sec. 3, and continues eastward up slope; offset begins at top of unit 13 in Morrison formation about 900 feet down dip slope in SW 1/4 sec. 2, T. 40 N., R. 83 W. Natrona County, Wyoming. Measured with Brunton and tape. Strike: N 3° E; dip: 6° S 87° E.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

Rusty Beds member: (in part)

20. Shale and siltstone, similar to unit 19 at section 1, that is, typical Rusty Beds member; a few polished pebbles occur as float on the Rusty Beds dip slope, but undoubtedly weathered out of Cloverly outcrop up dip

UNCONFORMITY

Cloverly formation: 25 feet thick
Otter Creek sandstone member

19. Sandstone, gray, white, tan, and brown, fine to coarse, moderately to well cemented, cross-bedded; includes conglomeratic lenses with pebbles of white chert and quartzite averaging 0.5 inch; includes ferruginous nodules randomly distributed; sparkly in places; prominent ledge; variable thickness 25.0

DISCONFORMITY

UPPER JURASSIC

Morrison formation: 210 feet thick

18. Mudstone, dark gray to black, silty, soft; with rusty staining; slope 37.0
17. Siltstone, gray, sandy, thin-bedded, soft; slope 11.0
16. Mudstone, dark gray-green, soft; slope; includes siltstone, gray-green, well cemented, slightly calcareous which occurs as 4-inch-thick ledge at top 25.0
15. Mudstone, dark gray, silty, soft; slope 14.0
14. Mudstone, red-brown, silty, calcareous, soft; slope 4.0
13. Sandstone, white, fine to coarse, moderately cemented, cross-bedded, calcareous; sparkly; includes ferruginous nodules, and rusty spots; conglomeratic in places; crops out as "shaly" ledge capping second cuesta west of Willow Creek; a few pieces of agatized wood occur as float on lower part of unit 13 dip slope 15.0
12. Sandstone, gray, fine, poorly cemented, calcareous, thin-bedded, with ferruginous nodules; grades upwards into gray-green very fine sandstone at about 11 feet above base, and into sandy gray-green mudstone at about 22 feet above base; slope 28.0
11. Sandstone, gray, fine, well cemented, calcareous, massive; includes ferruginous nodules; sparkly; ledge 1.0
10. Sandstone, red-brown with green, fine, soft, calcareous; slope 18.0
9. Sandstone, white, fine, well cemented, calcareous, cross-bedded; includes ferruginous nodules as much as 5 inches in long diameter; sparkly; ledge 19.0
8. Mudstone, gray-green, silty, calcareous, soft; slope 3.0
7. Sandstone, gray-green with pale red tint, fine, soft, calcareous; slope 4.0
6. Sandstone, white to gray, moderately cemented, calcareous, thin-bedded; sparkly; gradational with unit 5; ledge 5.0
5. Sandstone, similar to unit 3, but becomes pale red upwards 3.0
4. Sandstone, similar to unit 2, but not well exposed 1.0
3. Sandstone, red-brown, very fine, soft, calcareous; sparkly; slope 3.0
2. Sandstone, gray to white, fine, moderately cemented, calcareous, small-scale cross-bedded; sparkly; including very minor glauconite (?) grains; thins in both directions; ledge 4.0
1. Mudstone, chocolate red-brown, silty, soft, calcareous; with pale gray-green spots, zones, etc.; slope 15.0

Total Morrison and Cloverly 235.0

DISCONFORMITY

Sundance formation: (in part)

Sandstone, white to gray, medium, moderately cemented, calcareous, thin-bedded; with glauconite; with ripples; ledge 4.0
Shale, black; slope 41.0
Limestone, gray, with Belemnites; ledge 2.0

SECTION 20: SOUTHEAST BARNUM

Section measured on slope about 2 miles east of Bar C Ranch, and 5.5 miles S 50° E of Barnum, Wyoming. Section begins in Sundance formation in NW 1/4 sec. 17, T. 42 N., R. 83 W. Johnson County, Wyoming. Measured with Brunton and tape. Strike: N 30° W; dip: 6° N 60° E.

Feet

LOWER CRETACEOUS

Thermopolis shale: (in part)

Rusty Beds member: (in part)

25. Shale and siltstone, similar to unit 19 at section 1, that is, typical Rusty Beds member

UNCONFORMITY

Cloverly formation: 30 feet thick
Otter Creek sandstone member

24. Sandstone, white to gray to brown, fine to coarse and locally conglomeratic, moderately cemented, cross-bedded with dips generally inclined northwestward but readings unreliable as much slumping occurs; slightly sparkly, and sugary; top surface irregular as is common elsewhere, but much finer grained than elsewhere, with uppermost conglomeratic few inches only locally present; with ferruginous staining; variable thickness; prominent ledge 30.0

DISCONFORMITY

UPPER JURASSIC
Morrison formation: 215 feet thick

23. Slope with soil, vegetation, and rubble cover; probably dark gray mudstone on basis of fragments in soil 57.0
22. Mudstone, olive-green, silty, soft; becomes dark gray upwards; slope 22.0
21. Mudstone, red-brown, silty, soft, calcareous; includes rounded medium grains scattered throughout; slope 8.0
20. Limestone, gray, sandy, hard; ledge 0.5
19. Mudstone, red-brown, sparsely silty, soft; with green mottling upwards; slope 7.0
18. Sandstone, gray in lower part and gray-green in upper, very fine with scattered medium grains, soft, calcareous; slope 9.0
17. Sandstone, gray, very fine with scattered medium grains, calcareous; upper 0.5 foot well cemented and resistant but remainder of unit is soft and forms slope 5.0
16. Siltstone, gray, sandy, well cemented, calcareous; ledge 2.0
15. Siltstone, dark gray, sandy, soft; slope 9.0
14. Sandstone, gray, very fine, well cemented, calcareous; appears to thin out in both directions; ledge 0.5
13. Siltstone, dark gray, sandy, soft, calcareous in lower 2 feet; slope 10.0
12. Sandstone, gray to white, soft, calcareous; includes hard, well cemented uppermost 3 to 4 inches; includes scattered rounded medium and coarse grains; slope 4.0
11. Siltstone, similar to unit 9 but not sparkly 1.0
10. Sandstone, bright green to gray-green, very fine, soft, calcareous in lower part and non-calcareous in upper; slope 3.0
9. Siltstone, red-brown, sandy, soft; slope; sparkly 5.0
8. Siltstone, sandy to very fine sandstone, red-brown with green, soft, calcareous; slope 4.0
7. Sandstone, gray-green, fine, soft, calcareous; becomes pale green and very fine upwards; slope 12.0
6. Sandstone, gray to tan, medium to coarse, calcareous, cross-bedded, moderately cemented; channeled into unit 5 as much as 3 feet; includes ferruginous nodules throughout, but especially along bottom surface; sparkly; prominent ledge 40.0
5. Mudstone, dark gray, silty, soft, calcareous; variable thickness; slope 1.0
4. Sandstone, gray, fine, soft, calcareous, laminated; slope 2.0
3. Mudstone, red-brown, silty, soft, locally calcareous; slope 4.0
2. Sandstone, red-brown in lower part and gray-green in upper, very fine, soft, calcareous, thin-bedded; sparkly because of inclusion of large crystals of calcite along bedding surfaces; slope 6.0
1. Sandstone, gray-green, very fine, soft, calcareous; sparkly; includes 6-inch-thick chocolate-brown mudstone at top; slope 3.0

Total Morrison and Cloverly 245.0

DISCONFORMITY

Sundance formation: (in part)
Sandstone, gray to brown, medium, poorly cemented, calcareous, glauconitic, cross-bedded; fossiliferous; slope 5.0
Shale, black; slope ..... 10.0 +

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1933
GEOLOGICAL SURVEY