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STRATIGRAPHY OF THE SUNDANCE, NUGGET AND JELM FORMATIONS IN THE LARAMIE BASIN, WYOMING

by
George N. Pipiringos

UNIVERSITY OF WYOMING
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GEOLOGICAL SURVEY

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ABSTRACT

To determine stratigraphic changes in the marine Jurassic and related rocks of the Laramie Basin, sections were measured along a 90-mile line extending from the Freeze-out Hills, Wyoming, south to Bull Mountain, Colorado. The investigation warrants the following conclusions:

The Sundance formation (Upper Jurassic) is thickest in the northern part of the area and thins southward by onlap and intraformational erosion. The Sundance of the Laramie Basin contains two new members in addition to the members of the type Sundance defined by Imlay. New member A overlies the Redwater shale member of the Sundance; new member B underlies it. Member A bevels the underlying beds and probably is of Kimmeridgian age. It is present in all sections, contains marine fossils in the northern part of the area, but intertongues with variegated beds of continental origin of the Morrison formation (Upper Jurassic) in the southern part of the area.

The Redwater shale member contains marine fossils of Oxfordian age, is thickest in the north, but disappears by erosion a few miles south of Centennial, Wyoming.

The Redwater shale is separated from the underlying member B by a disconformity marked by a sharp lithologic change. The disconformity is widespread areally, but represents only a small span of time. The stratigraphic position and faunal content of member B indicate it is of late Callovian age.

Member B is in turn separated from the underlying Lak member by a disconformity marked by a sharp change in lithology. In the Freezeout Hills area the Lak member consists of non-fossiliferous massive sandstone redbeds. The Lak thins southward, and thinning is accompanied by a change from redbeds to beach-type buff or white sandstone. It is present at the Como Bluff section but cannot be recognized in sections south of that locality.

The Lak grades downward into the Hulett sandstone member which in turn grades downward into the highly fossiliferous Stockade Beaver shale member. Both the Hulett sandstone and the Stockade Beaver shale thin from north to south within the Freezeout Hills area, and are absent in sections farther south. No ammonites or specimens of Trigonia were found in these members, but they and the Lak are most probably of early Callovian age.

The Stockade Beaver shale grades downward into the Canyon Springs sandstone member, which is present throughout the examined area. It was derived from the underlying Nugget sandstone (Lower Jurassic), on which it rests with inconspicuous disconformity, when the Callovian sea (Twin Creek sea) transgressed southward across the Nugget. The hiatus between the Sundance and Nugget represents all of Middle Jurassic time and possibly part of Early Jurassic time.

The Nugget of this paper constitutes the upper part of the original Jelm formation, and is here correlated with the upper part of the Nugget sandstone of central Wyoming and with the so-called Entrada sandstone in the northern part of the Colorado Front Range.

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* Graduate student in geology at the University of Wyoming at the time of preparation of this paper; at present, geologist, U. S. Geological Survey.

The name Jelm is therefore restricted to rocks below the Nugget and above the Alcova limestone member of the Chugwater formation. South of the Freezeout Hills the Alcova is absent and the Jelm formation rests on the redbeds comprising the main body of the Chugwater. The Nugget sandstone and the Jelm formation are present throughout the area discussed in this report.

The type Jelm (restricted) is here divided into an upper conglomeratic sandstone member which grades up into the Nugget, and a lower member consisting mostly of conspicuous massive or thick-bedded orange-pink sandstone and lesser amounts of redbed claystone and siltstone. The upper Jelm persists with little change throughout the area, and includes a limestone pebble conglomerate, usually near the base, which contains fragments of fossil wood and fossil bone. In the northern part of the area, the sandstone of the lower Jelm is thinner bedded, white or gray, and is inconspicuous by comparison with the brightly colored redbeds part. The upper member of the Jelm quite likely correlates with the lower reddish part of the Nugget of central Wyoming, and is probably of Late Triassic age. The lower member of the Jelm quite likely correlates with the Popo Agie formation of central Wyoming and is probably also of Late Triassic age.

The Alcova limestone member of the Chugwater formation is conspicuous in the Freezeout Hills area and contains fossil mollusks of probable Early Triassic age. The Alcova might be of Middle Triassic age, but is unlikely to be of Late Triassic age.

INTRODUCTION

In the Laramie Basin of southeastern Wyoming (Fig. 1), the succession of rocks lying between the Chugwater formation (Triassic) and the Morrison formation (Jurassic) has not been studied as intensively as have rocks of similar lithologic and stratigraphic aspect in other areas.

This paper is based on the results of field work undertaken in the late summer of 1947 to fulfill in part the requirements for the M. A. degree at the University of Wyoming. The preliminary results of this investigation were presented before the Geological Society of America (Pipiringos, 1948). The conclusions given there and in the thesis itself (Pipiringos, 1948a) concerned the correlation of the rocks studied within the Laramie Basin, and were based primarily on lithologic considerations and to some extent on faunal content. As presented here the original conclusions are considerably strengthened by a more thorough study of the fossils, and an attempt is made to show how the implications inherent in these conclusions affect the correlation and interpretation of similar stratigraphic units in other areas. An abridged version of this paper appeared in the 1953 Guidebook of the Eighth Annual Field Conference of the Wyoming Geological Association (Pipiringos, 1953).

ACKNOWLEDGMENTS

The sections in the Freezeout Hills and Flattop Anticline were studied with the able assistance of Robert H. Erickson. The writer and his assistant are grateful to Mr. and Mrs. Denver Miller, owners of the TB ranch in the eastern part of the Freezeout Hills, who have furnished two generations of University of Wyoming students free lodgings during work op nearby thesis areas. Drs. S. H. Knight, H. D. Thomas, D. L. Blackstone, Jr., (University of Wyoming), Drs. R. W. Imlay, J. D. Love, N. M. Denson (U.S.G.S.), and former fellow students P. L. Gooldy, Frank Sims and George DeVore are due thanks for assistance rendered in many ways. Dr. Charles T. Berry kindly identified specimens of fossil brittle stars.

METHODS OF STUDY

Sections were measured in detail using a Brunton compass, and in the case of the Freezeout Hills and Flattop anticline sections, remeasured with telescopic alidade and plane table. Samples from each rock unit examined in the field were studied with a binocular microscope. Fossils were collected and identified by the writer, but the ammonites were identified by Dr. Ralph W. Imlay, of the U. S. Geological Survey.

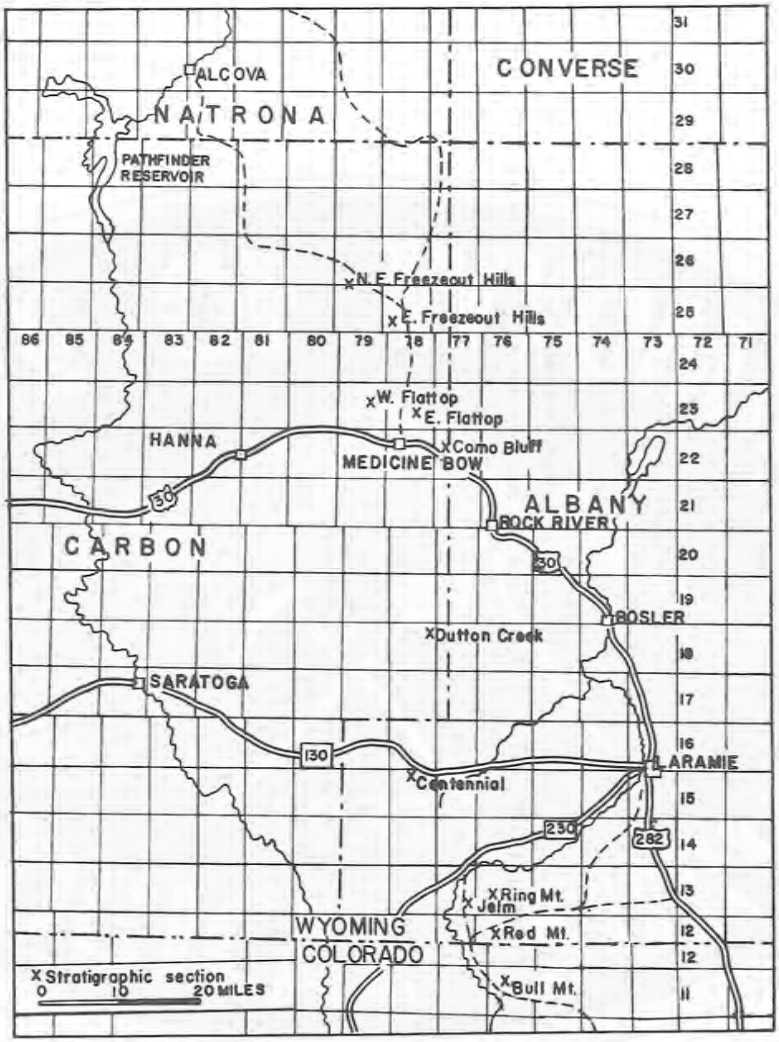

Figure 1. - Index map showing location of measured sections.

SUMMARY OF PREVIOUS WORK

The reader is referred to the paper by Joseph Neely (1937) for a comprehensive review of the work done on the Sundance formation and the Nugget (?) sandstone prior to 1937. With regard to more recent investigations, the reader is referred to the works of Ralph W. Imlay (1945 et seq.).

Darton (1899) applied the name Sundance formation to the marine Jurassic strata of the Black Hills area.

Knight (1900) described the Jurassic rocks of southeastern Wyoming. He applied the name "Como Stage" (now the Morrison) to the non-marine sediments, and the name "Shirley Stage" (now the Sundance) to the marine deposits.

Logan (1900) described the stratigraphy and invertebrate paleontology of the Freeze-out Hills area. He placed the "Jura-Trias" boundary at what appears to be the top of member B of this paper.

Logan (1900a) outlined the limits of the interior Jurassic sea and expressed the opinion that the marine Jurassic rocks of eastern Wyoming represented one faunal and lithologic unit.

Schuchert (1910) wrote:

> Logan Sea--an extensive, late Jurassic, western continental sea of very short duration, with northern Pacific connection. . . . The sea was correctly mapped by W. H. Logan, for whom it was named.

In the same paper (p. 580) he wrote:

> . . . at or near the close of the Middle Jurassic, . . . there appeared . . . the Logan Sea bringing in for a short time . . . Cardioceras cordiforme . . . and the cephalopod Belemnites densus.

Darton (1908) expressed the opinion that the Jurassic succession of part of central Wyoming was the equivalent of the Jurassic rocks of the Black Hills area.

Knight (1917, p. 168) recognized the upper 250 feet of what was then included in the Chugwater formation to be:

> . . . a distinct formation, to be known as the Jelm formation, from the good exposures of the characteristic bone bearing conglomerate near the east base of Jelm Mountain.

Jelm Mountain lies just east of Woods Landing, about 4 1/2 miles northwest of Section VII of this paper. Knight thought the Jelm to be Triassic in age.

Reeside (1919) collected and described a large number of ammonites from the Sundance, some of which came from the areas in which Sections II, IV and V of this paper were measured. He concluded that the Sundance was characterized by the ammonite genus Cardioceras, and thus belonged to the Lower Oxfordian stage of lower Upper Jurassic age.

Lee (1927, p. 15) divided the Sundance of central and eastern Wyoming into four members. He stated:

> In order from base to top these are a massive basal sandstone; a member composed of flaggy sandstone, sandy calcareous shale, and brittle cherty limestone containing a few marine fossils; a red gypsum-bearing member in which no fossils have been found; and an upper member consisting of sand, shale and limestone that contain great numbers of fossils, which constitute the well known Sundance fauna.

Lee thought the Sundance thinned from northwest to southeast by erosion.

Lee recognized the Jelm formation in the Laramie Basin, and noted the occurrence of similar rocks north of Medicine Bow, "where fragments of bone were found in a pellet conglomerate."

In the same publication (p. 14) Lee named the Alcova limestone member of the Chugwater formation from exposures near the town of Alcova, Wyoming. He remarked on the puzzling behavior of the Alcova:

> There is no indication that its disappearance toward the east is due to non-deposition. It continues eastward with full thickness and unchanged character to the last exposure. Indeed, it is more prominent in the Freezeout Hills than it is at most of the more westerly exposures.

Crickmay (1931) assigned the Sundance of eastern Wyoming to the Argovian-Kimmeridgian (European stages) because of the fauna which is characterized by the ammonite genus Cardioceras.

Crickmay (1936) divided the Sundance into three members; lower, upper and middle Sundance. The basal member consisted of sandstone and red shale. The conspicuous sandstone present in this member was thought to be the possible lithologic equivalent of the basal Ellis sandstone of Montana. He stated: ". . . the continuity of this basal bed in each region suggests strongly that it lies above the Triado-Jurassic disconformity." Crickmay's middle Sundance was said to be characterized by the ammonite Cardioceras distans. He believed that most of the Cardioceras forms reported from this interval were probably misidentified and that they belonged to other younger genera characterizing his upper Sundance member.

Neely (1937) divided the Sundance formation into upper Sundance and lower Sundance. The division was based on a major erosional surface which Neely considered to be present within the Sundance formation. He correlated the upper Sundance with "the Preuss and the Stump formations of western Wyoming and southeastern Idaho . . . [with] the upper portion of the Ellis formation of northwestern Wyoming, or the Sundance formation as it has been re-defined by Crickmay." He considered the lower Sundance to be equivalent to a part of the Twin Creek limestone of western Wyoming.

In the same publication, Neely tentatively correlated the thick sandstone that occurs at the base of the Sundance formation in the Freezeout Hills with the Nugget sandstone of western Wyoming. He believed the Nugget (?) sandstone was limited to the Freezeout Hills area and advanced the suggestion that this limited occurrence was the result of deposition in an isolated depression. He based this correlation "solely on lithologic similarity, stratigraphic position, and the evidence of an unconformable relationship at the top of the sandstone." He further added (1937, p. 747):

> Bartram (1930) has correlated the basal Sundance sand with the Nugget (?) formation and believed that this can be traced from western Wyoming to the Black Hills. However, the presence of a marine fauna not found in the Nugget, in the basal Sundance sandstone at certain localities, and the absence of any evidence of an erosion surface at the top of the basal sandstone, tends to disprove this correlation for all of the localities except that in the vicinity of Freezeout Hills.

Imlay (1947) made a restudy of the type Sundance formation. As a result of this investigation, he subdivided the Sundance into five members. These are, from top to bottom: (1) the Redwater shale member; (2) the Lak member; (3) the Hulett sandstone member; (4) the Stockade Beaver shale member; and (5) the Canyon Springs sandstone member. The Redwater shale is abundantly fossiliferous and, on the basis of the fauna, was correlated by Imlay with the upper portion of the Sundance of the Big Horn Basin (northern part), with the "Upper Sundance" of the Wind River Basin, and with parts of other formations in Wyoming, Montana, Idaho and Utah. Imlay (1947, p. 258) stated:

> The Lak member is correlated on the basis of stratigraphic position with the redbeds at the top of the "Lower Sundance" in central Wyoming, with the Preuss sandstone of westernmost Wyoming and eastern Idaho and with at least part of the Entrada sandstone of eastern Utah.

He (Imlay, 1947, p. 257) also stated:

> A disconformable relationship with the overlying Redwater shale member is indicated by an abrupt change from unfossiliferous redbeds to highly fossiliferous sandstone and shale and possibly by the marked local variations in thickness of the Lak member.

The Hulett sandstone member is fossiliferous, but the ranges of the pelecypods found therein "are not known well enough to permit close correlations with the Jurassic beds of Wyoming or Montana." Imlay "prefers to correlate the Hulett sandstone member with the Kepplerites (Seymourites) beds at the top of the Rierdon formation in Montana, on the basis that the middle and upper parts of the Stockade Beaver shale member seem to represent the Gowericeras beds" (Imlay, 1947, p. 256). The Hulett sandstone member grades into the underlying Stockade Beaver shale member. The lower part of the Stockade Beaver shale member contains ammonites of the genus Arcticoceras. The upper and middle part of this member contain a few specimens of Gryphaea. Since Gryphaea nebrascensis first appears in Gowericeras beds elsewhere in Wyoming and Montana, it is presumed that the middle and upper parts of the Stockade Beaver shale may be referred to the Gowericeras zone. The Stockade Beaver shale member appears to rest conformably on the underlying member.

The Canyon Springs sandstone is the basal member of the redefined type Sundance. It is lenticular and rests disconformably on the underlying Gypsum Spring formation. The sandstone contains Arcticoceras, which establishes its close relationship with the overlying Stockade Beaver shale member.

Imlay recognized the presence of the Gypsum Spring formation in some places in the Black Hills. The Middle Jurassic age which Imlay gave for this formation was based on faunal content and local and regional stratigraphic relationships.

The possible occurrence of the Nugget sandstone in the southwestern part of the Black Hills was recognized by Imlay (1947, p. 236), who stated:

> Definite identification of the Nugget (?) sandstone in the Black Hills must await subsurface studies . . . its occurrence there seems possible inasmuch as it has been traced with reasonable certainty as far east as the Hartville uplift.

STRATIGRAPHY

TYPE AREA OF THE SUNDANCE FORMATION

The first notice of the presence of marine Jurassic rocks in the western interior was given by Meek (1858) who identified fossils collected by Hayden from the Black Hills. In 1899 Darton (p. 387) named the following formations in the Black Hills:

Age	Formation	Thickness
Lower Cretaceous	Lakota	
(or Jurassic?)	Beulah	0 - 100'
Jurassic	Unkpapa	0 - 225'
	Sundance	60 - 400'
Triassic	Spearfish	

Darton (1899, p. 389) recognized and briefly discussed the five units of the Sundance formation later named as members by Imlay (1947). He said (1899, p. 389):

> The succession of the lower dark shales [Stockade Beaver], a slabby, buff, ripple-marked sandstone next above [Hulett], a reddish sandy shale [Lak], and an upper green shale with fossiliferous limestone layers [Redwater], is continuous over a wide area. At the base of the formation there is often a massive sandstone [Canyon Springs] of a red or buff color occurring in extended lenses and often attaining a thickness of 25 feet.

On p. 392, in the description of the section near Minnekahta, Darton described the basal sandstone as, "red, coarse, massive, and fossiliferous."

Darton described a number of stratigraphic sections of the Sundance formation as exposed at various places around the Black Hills uplift. Paradoxically, all outcrop areas of the Sundance are described except that in the vicinity of Sundance.

At the top of the Sundance formation at several localities, Darton noted a sandstone 15 to 25 feet thick, generally slabby below, massive above and buff in color although locally "red." Of this unit he said (1899, p. 391):

> The sandstone at the top of this section is a very conspicuous member for some miles on either side of Spring Creek [Eastern Black Hills], and it appears to have developed out of the sandy beds which usually overlie the upper green shales [Redwater] southward. It is possible, however, that it is a representative of the lower portion of the Unkpapa sandstone which is thin in this vicinity.

Imlay (1947, p. 260) noted 5 to 10 feet of soft yellow sandstone in a section about 9 miles northwest of Spearfish, South Dakota, at the top of the type Redwater shale member, and a 5-foot yellow soft medium-bedded sandstone in the same stratigraphic position near Minnekahta, in the southern Black Hills (Imlay, 1947, p. 269), and a 30-foot soft yellow sandstone "that is possibly correlative with the Unkpapa sandstone" at the top of a section measured 2.5 miles north of Hulett, in the northeastern Black Hills (Imlay, 1947, p. 270).

The exposures of the Sundance formation near the town of Sundance were deemed unsatisfactory as a type section, and Imlay (1947, p. 245) selected instead, "one of the best exposed, most complete, and most accessible sections in the Black Hills as a standard of reference." This type section was measured one mile north-northeast of the center of the town of Spearfish, South Dakota. In this section Imlay noted that the basal beds of the Morrison consist of "fine-grained, pseudo-oolitic, yellow sandstone." The writer believes that this sandstone* is the equivalent of the sandstone at the top of the Sundance of the Laramie Basin. It will be discussed later as member A of the Sundance formation.

AGE OF THE TYPE SUNDANCE FORMATION

Workers prior to 1937 (Stanton, 1899, p. 604; Reeside, 1919, p. 10; Crickmay, 1936, p. 552, etc.) considered the Sundance of eastern Wyoming to be of post-Callovian age. In that year Neely published the results of a study of the Jurassic rocks of Wyoming. He correlated the lower part of the Sundance formation of eastern Wyoming with the Twin Creek formation and with the Ellis formation of Crickmay ("Lower Ellis" of previous workers, now subdivided into Sawtooth and Rierdon formations, Cobban, 1945). Since Crickmay considered his Ellis to be of Callovian age Neely inferred that the lower part of the Sundance formation of eastern Wyoming likewise was of Callovian age. Imlay (1947) in effect

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* On p. 245 (Locality 2), the sandstone is placed at the base of the Morrison. On p. 270 (Locality 6, bed 18), it is placed at the top of the Redwater and questionably correlated with the Unkpapa sandstone. On p. 266 (Locality 1, top of bed 22), and on p. 269 (Locality 5, beds 13 and 14), it is included in the Redwater shale.

substantiated the inference, and by comparing ammonites from the Black Hills Jurassic and many other localities in the Western Interior, with those indicant of the European Jurassic stages as set forth by Arkell (1946) (see Table 1) was able to establish a fairly elaborate correlation with the European Jurassic. The Redwater shale member of Imlay (roughly equivalent to the "Upper Sundance" of eastern Wyoming) contains ammonites of early Oxfordian age while the lowest two members (Stockade Beaver and Canyon Springs) have yielded specimens of Arcticoceras, Gowericeras and Cadoceras of early Callovian age. The Hulett sandstone is moderately fossiliferous but has not yielded any ammonites, so that a middle Callovian age is inferred by correlation with the Kepplerites (Seymourites) beds near the top of the Rierdon formation of Montana. The redbed member (Lak) is unfossiliferous, but is assumed by Imlay to be Callovian inasmuch as it appears to be separated from the overlying Redwater shale member by an erosional disconformity which he correlates with the disconformity between the Swift and Rierdon formation of Montana (Cobban, 1945).

TYPE AREA OF THE NUGGET FORMATION

The type area of the Nugget formation is in Lincoln County, southwestern Wyoming. The formation was named by Veatch (1907, p. 56) from good exposures in the northwestern part of T. 21 N., R. 118 W., about 15 miles west of Kemmerer, near Nugget Station on the Oregon Short Line railroad. The type Nugget, 1,900 feet thick, overlies the Thaynes and underlies the Twin Creek formations. It was divided into two members which Veatch mapped separately. The upper member consists of thin-bedded light yellow sandstone and shale about 1,000 feet thick, and the lower redbed member consists of bright red sandstone and shale 600 feet thick.

Inasmuch as Boutwell (1907, p. 453-5) applied the name Ankareh to a 1,300-foot sequence in the Park City mining district, Utah, whose stratigraphic position is identical to that of the original Nugget formation (resting on the Thaynes and overlain by the Twin Creek), subsequent workers (Gale, 1910; Gale and Richards, 1910; Richards and Mansfield, 1911; Boutwell, 1912; Schultz and Richards, 1913; Mansfield, 1916, 1920, 1927; Heaton, 1939; Thomas and Krueger, 1946; Baker, 1947; Huddle and McCann, 1947; Kummel, 1954) in adjacent and intervening areas have tried to retain both names, not as equivalents, but by restricting the name Ankareh to the basal redbed unit of the original Ankareh and Nugget formations, and by restricting the name Nugget to the overlying thick sandstone unit. These workers did not agree among themselves as to where the Nugget-Ankareh boundary should be drawn, and consequently to this day there is very little agreement as to what names to use for the various lithologic subdivisions in the sequence overlying the Thaynes and underlying the Twin Creek formation. The absence of detailed measured sections in the literature of either of the type sections prevents the reader from forming some opinion of how these sections correlate, and which of the various systems of nomenclature applied to similar rocks in adjacent areas (Mansfield, 1927; Williams, 1945; Thomas and Krueger, 1946; Baker, 1947; Huddle and McCann, 1947; and Kummel, 1954) should be applied in the type Nugget area. Likewise no exact notion of the lithology of the Nugget can be formed by the reader for the same reasons.

Presumably the Nugget sandstone (upper member of the Nugget formation of Veatch) is similar to the Nugget of central Wyoming as described by Love et al. (1945 and 1947) and consists of cross-bedded massive pink and white sandstone in the upper part, and of reddish to white sandstone interbedded with siltstone and shale redbeds in the lower part.

AGE OF THE TYPE NUGGET FORMATION

Veatch (1907) considered the Nugget in whole or in part Triassic, because of its position above Upper Carboniferous limestones and below beds containing Jurassic fossils. Gale (1910), and Gale and Richards (1910), considered the Nugget sandstone (equivalent to the upper member of the Nugget formation of Veatch) as of either Early Jurassic or

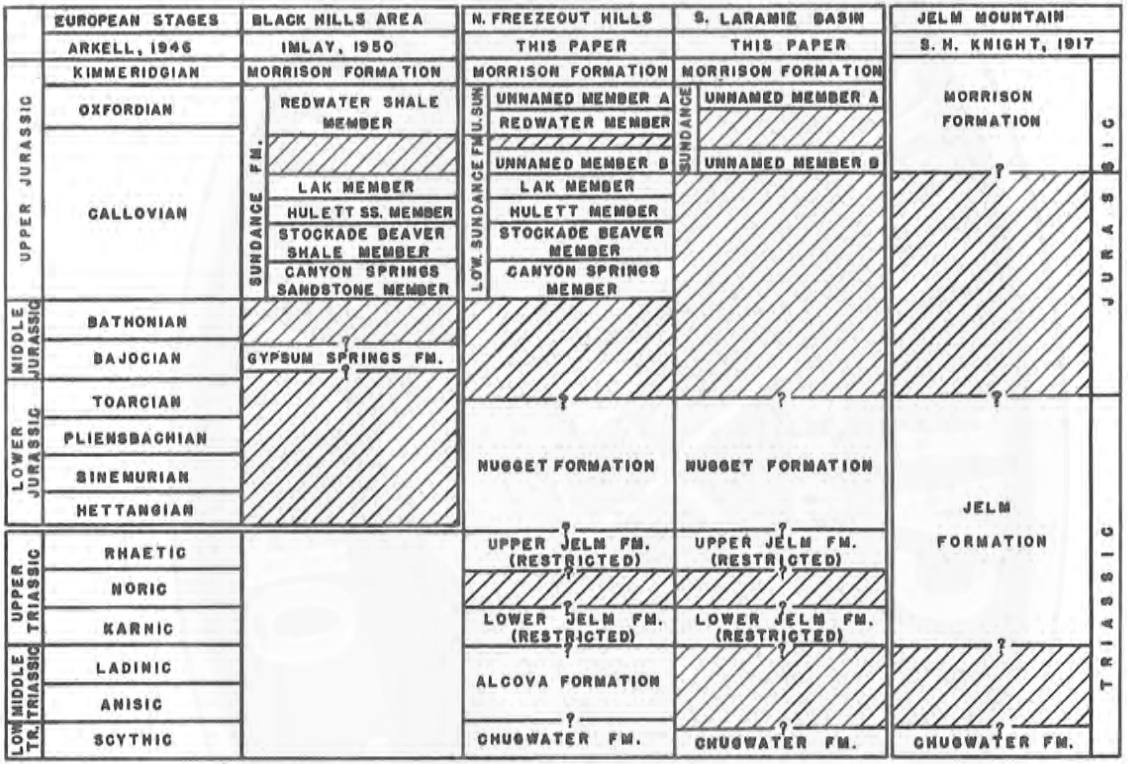

Table 1. - Suggested correlation and age relationships of the rocks discussed in this paper with the type Sundance and Jelm formations.

Triassic age, and that the upper part of the Nugget at least was probably Jurassic. Mansfield referred the Nugget to the Jurassic in 1920 (p. 54).

In areas adjacent to, and presumably at the type locality of the Nugget, the beds overlying it are of probable early Middle Jurassic age (Imlay, 1950), so it seems unlikely that the type Nugget can be younger than Early Jurassic. Although the redbeds underlying the type Nugget have not been dated, they probably correlate with the Late Triassic Stanaker and Chinle formations to the south in the Uinta Mountains, (Thomas and Krueger, 1946, section 8; Huddle and McCann, 1947; and Kummel, 1954, pl. 34, sections 25, 26, 27). These relationships make it seem likely that the Nugget sandstone is probably of Early Jurassic age, but may be of Late Triassic age in the lower part.

TYPE AREA OF THE JELM FORMATION

Concerning the redbeds of the Laramie Basin, S. H. Knight, in 1917 (p. 168-169), differentiated the upper 250 feet of what was then included in the Chugwater formation, and named that interval the Jelm formation, "from the good exposures of the characteristic bone-bearing conglomerate near the east base of Jelm Mountain." He noted that the Jelm formation was separated from the underlying Chugwater formation by a disconformity, and correlated the Jelm with the Dolores formation of Colorado on the basis of identical conglomerates and on the similar stratigraphic position of the two formations.

Lee (1927) treated the Jelm as a unit separate from a massive cliff-making sandstone which he called the basal sandstone member of the Sundance. He stated that these two units continue southward into Colorado as far as Owl Creek. He noted the presence of conglomeratic material similar to that of the type Jelm north of Medicine Bow, "near Rawlins, at Whiskey Gap and near Lander." He traced the basal Sundance sandstone north as far as Douglas. He stated (p. 16):

> This sandstone has the general appearance and character of the massive Jurassic sandstones farther west and south that have been called Nugget, White Cliff, La Plata, Navajo, Exeter, etc.

Although his line of sections passes through the type Jelm area (his section 41 in particular, and his photograph of the basal Sundance sandstone at "Steamboat Lake", Pl. 24, B) he did not indicate the relationship between the basal sandstone member of the Sundance formation and the type Jelm formation.

Heaton (1939, p. 1158) examined the Bull Mountain, Colorado, section (Section X of correlation chart, Pl. 7) and concluded that the Jelm formation (in the original sense) consisted of an upper part which he correlated with the Entrada and of a lower part which he correlated with the Wingate.

Sections VII, VIII, and X of this paper are typical of the Jelm formation, which is divisible into three parts. The lower one consists of orange-pink massive cross-bedded sandstone which contains numerous thin interbeds of red claystone. The sandstone usually is bleached white where it is in contact with claystone.

The middle part is a slabby "trashy" sandstone which includes, usually at the base, the characteristic fossil wood and fossil bone-bearing conglomerate. The upper part is massive cross-bedded sandstone very similar in color to the lower part, but differs from it in the absence of red shale and claystone partings, in the absence of mica flakes and abundant dark mineral grains so common in the lower part, and in that it is often buff or yellow-white in color.

The upper part of the original Jelm formation is here correlated with the upper part of the Nugget sandstone of west-central Wyoming, and with Lee's "basal Sundance sandstone", while the name Jelm is retained for the remainder, which underlies the Nugget sandstone of this paper and overlies the Chugwater formation.

AGE OF THE TYPE JELM FORMATION

No direct evidence for the age of the Jelm has been advanced since the original suggestion by Knight (1917) that it is of Triassic age. This age assignment was based on fossil vertebrate fragments and by correlation with the Dolores formation of Colorado. The writer believes that the upper part of the Jelm (Nugget of this paper) is of Early Jurassic age, that the lower part is of Late Triassic age, and that the middle conglomeratic part may be either. The middle part resembles the overlying Nugget sandstone which suggests a Jurassic age, but the fossils it contains appear to be of Triassic age (Knight, 1917). The age of the type Jelm will be further discussed below.

GENERALIZED STRATIGRAPHIC SECTION

The Northeast Freezeout Hills section is the most complete of those measured, and the lithologic and/or faunal aspects of the formations and members present there are typical enough to enable one to recognize them, where present, southward as far as Owl Canyon, Colorado. Therefore, this section is presented as the standard section of the Sundance formation in the Laramie Basin. The distribution and thickness of these units within the area studied is given in Table 2.

Morrison Formation

10'+ Interbedded limestone, sandstone and claystone, green-gray.

Sundance Formation

Member A: 15' Buff sandstone, black claystone, tan limestone; calcareous throughout, pseudo-oolitic, contains glauconite, chert nodules and marine fossils; ripple-marked, makes slabby ledge.

Redwater shale member: 94' Greenish-black calcareous shale and siltstone; contains thin sandy limestone interbeds and smooth dense septarian limestone concretions; is conspicuously glauconitic, oolitic and fossiliferous throughout; contains Cardioceras sp. at the base. Pachyteuthis "densus" is common, especially in the lower half. Makes ledgy slope.

Member B: 13' Sandstone and siltstone, green-white, weathers gray-brown, fine-grained, contains green clay inclusions and 2 feet of red-brown sandstone near middle; sparsely glauconitic and oolitic; massive and cross-laminated below, slabby and ripple-marked above; ledge-maker.

Lak member: 32' Redbeds. Sandstone, fine-grained, limy, massive, soft, makes sandy slope. The basal 6' is greenish-white.

Hulett sandstone member: 13' Sandstone, green-white to buff, fine-grained, limy, massive, soft; locally ripple-marked, makes rounded ledges. Contains thin green shale partings.

Stockade Beaver shale member: 35' Fine-grained sandstone, limestone, shale, and siltstone, in beds 1/2 to two feet thick. Uniformly gray-green, limy throughout, fossiliferous, makes ledgy slope. Contains pelecypods, crinoid stems, and a few brittle stars. The basal 10 feet consists of gray-white very fine grained sandstone containing numerous orange and brown rounded quartz grains. The sandstone is moderately hard, massive to obscurely bedded, sparsely fossiliferous, and weathers into vertical rough knobby faces capped by a 3-foot ledge-former.

Canyon Springs sandstone member: 10' Sandstone, yellow-white, weathers yellow-buff, very fine grained, limy. Lithologically similar to the underlying Nugget sandstone;

FORMATIONS AND MEMBERS		THICKNESS IN FEET; a stands for absent									LOCATION OF MEASURED SECTIONS
SUNDANCE	Member A	16	30	12	10	9	8	4	10	10	I - NW 1/4 and SE 1/4 SE 1/4 sec. 33, T. 26 N., R. 79 W.
	Redwater shale	94	83	71	63	30	11	a	a	a	
	Member B	13	32	59	45	36	26	29	19	16	II - W 1/2 SW 1/4 sec. 29, T. 25 N., R. 78 W.
	Lak member	32	33	31	13	12	a	a	a	a	
	Hulett sandstone	13	13	a	a	a	a	a	a	a	III - SE 1/4 NE 1/4 sec. 22, and SW 1/4 NW 1/4 sec. 23, T. 23 N., R. 78 W.
	Stockade Beaver shale	35	5	a	a	a	a	a	a	a	
	Canyon Springs sandstone	10	10	?	6	?	?	?	?	?	V - SE 1/4 NE 1/4 sec. 18, and SW 1/4 NE 1/4 sec. 18, T. 22 N., R. 77 W.
Total thickness of Sundance		213	206	173	137	87	45	33	29	26	
NUGGET SANDSTONE		40	90	63	60	77	110	86	53	43	XI - Union Oil Co. well in NE 1/4 SW 1/4 SE 1/4 sec. 1, T. 18 N., R. 78 W.
JELM	Upper member	50	30	30	5-14	28	24	30	49	40	VI - SW 1/4 SW 1/4 NW 1/4 sec. 3, T. 15 N., R. 78 W.
	Lower member	87	108	123	110	?	36	164	142	135	
Total thickness of Jelm		137	138	153	124	28	60	194	191	175	VII - SW 1/4 NE 1/4 sec. 35, T. 13 N., R. 77 W.
ALCOVA LIMESTONE		11	14.5	a	a	a	a	a	a	a	
		I	II	III	V	XI	VI	VII	VIII	X	VIII - SW 1/4 NW 1/4 sec. 16, T. 12 N., R. 76 W.
(North)		NORTHEAST FREEZEOUT HILLS	EAST FREEZEOUT HILLS	EAST FLAT TOP ANTICLINE	COMO BLUFF	DUTTON CREEK (AFTER H. D. THOMAS)	CENTENNIAL	JELM	RED MOUNTAIN	BULL MOUNTAIN, COLO.	X - SE 1/4 SW 1/4 SW 1/4 sec. 9, T. 11 N., R. 76 W. (South)

Table 2. -- Thickness of formations and members, from north to south, Laramie Basin, Wyoming

differs from it only in that the Canyon Springs sandstone contains more limonitic material, often layered rather than nodular, and in being plane-bedded rather than cross-bedded. In the West Flat Top Anticline Section (IV) the Canyon Springs sandstone is ripple-marked, a feature not present in the Nugget sandstone of this area.

Nugget Sandstone

40' Sandstone, yellow-white, weathers yellow buff to gray, very fine grained, limy. Contains numerous medium to coarse well rounded quartz grains that are clear, white, red, orange, brown, and gray, and are especially abundant along cross-bedding surfaces. Limonite nodules are scattered throughout. This unit makes a steep cliff.

Jelm Formation (restricted)

Upper member: 50' Sandstone, green-gray, weathers brown-gray, fine-grained above, medium-grained below, lime-cemented, moderately hard. The lower half is cross-bedded, makes a slabby ledge and contains pebbles and cobbles of limy siltstone, sandstone, and sandy limestone at the base. The largest of these is 4 inches long. In addition, dark mineral grains, flakes, and large rounded quartz grains are abundant. The upper half of this unit is poorly exposed but appears to consist of ledgy yellow-buff and pink sandstone.

Lower member: 87' Interbedded sandstone, shale and siltstone. The sandstone is white, locally orange-pink, weathers greenish- to grayish- white, very fine to fine-grained, limy, contains numerous dark grains and flakes and some rounded orange, red, yellow and black grains. The sandstone weathers into slabby ledges or low cliffs.

The shale and siltstone beds are red and green, identical to those found in typical redbeds.

Chugwater Formation

Alcova limestone member: 11' Limestone, separated into several beds 1 to 4 feet thick, colored gray-black, purple- to green-brown, green-gray and gray-white; overall color purplish gray. The upper and lower parts are sandy. The upper part contains ooliths resembling globose multichambered planispiral foraminiferal tests. This bed is glauconitic and fossiliferous throughout, and forms a prominent dip slope and ledge. Crinkled in lower part.

Main body of Chugwater formation: 400'+ Redbeds, not measured.

DISCUSSION OF FORMATIONS

Chugwater Formation

Alcova limestone member. - The Alcova of the Freezeout Hills, as elsewhere, is a thin-bedded, slabby, "crinkly" limestone; it nearly always forms spectacular hogbacks and dip slopes. One feature of interest at the Freezeout locality is the abundance, in the upper part, of coarse-size brown calcite bodies that resemble multichambered globose planispiral foraminifers, but which, when thin-sectioned, show the concentric-shelled structure characteristic of ooliths (Scott Warthin, personal communication, 1948). These might well be called compound ooliths.

The thickness of the Alcova limestone varies from a maximum of about 20 feet in the vicinity of Alcova, Wyoming, the type locality, to a vanishing edge to the northwest in the vicinity of the Red Grade and Horse Creek sections in Wind River Basin, Wyoming (Love, et al., 1947). It is also present in Jackson Hole farther to the northwest. The Alcova disappears by erosion to the north, northeast, and east of Alcova, in the southern part of the Big Horn Basin, in the extreme southwest corner of the Powder River Basin (Anon., 1949), and in the Glendo area (Love, et al., 1949; Denson and Botinelly, 1949; Downs,

1952). It is reported present east of the Freezeout Hills, by Konkel (1935, p. 18), a few miles southwest of Marshal, but absent some six miles south of the area mapped by Konkel (Giddings, 1935). The manner of its disappearance between these two areas is unknown. The Alcova is of more than average thickness in the East Freezeout Hills, but no trace of it could be found in Flat Top anticline some 13 miles to the south. In view of its greater than average thickness (14.5'), and its great persistence in other areas, even when quite thin, the writer felt that the Alcova disappeared southward by erosion; but recent subsurface studies by Burk (1953) strongly indicate that it is absent by reason of nondeposition.

According to Curtis (1951) and to Burk (1953), the Alcova limestone is present along the northern parts of the Hanna and Shirley basins, but disappears abruptly to the southeast, probably by nondeposition. The Alcova is present on the surface in the Miller Hill anticline (Larson and Vieaux, 1951), 22 miles southwest of Rawlins; and in the subsurface of central Wyoming at Lost Soldier oil field and Bison Basin. South and west of these points the extent of the Alcova limestone is not known (Curtis, 1951).

The Alcova limestone, whether lithologically continuous or lenticular, may correlate with some part of the Thaynes formation of western Wyoming. Correlation with this formation does not necessarily imply an Early Triassic age inasmuch as the thin limestone unit at the top of the Thaynes in the Sublette Ridge area of western Wyoming, in a stratigraphic position similar to that of the Alcova of the Rawlins Uplift, is not yet dated. In the Sublette Ridge area this lone eastward extension of the Thaynes formation is 12 feet thick and unfossiliferous. Where it is 67 feet thick at Hot Springs, Idaho, the lower part contains pelecypods and brachiopods, but diagnostic ammonoids are absent (Kummel, 1950). At Paris, southeastern Idaho, not very far northwest of Hot Springs, Kummel (in the same publication) correlates a 1,500-foot sequence of non-red limestone and shales with the upper limestone member and with the upper red shale member of the Thaynes formation of Hot Springs, Idaho. These members are 67 and 508 feet thick respectively. From the lower half of the 1,500-foot sequence in the Paris area, Kummel collected the ammonoid Arctoceras which he states is characteristic of the highest beds of the highest faunal zone (Prohungaritan) of the Lower Triassic of Spitzbergen as described by Spath. The upper part (some 750 feet thick) of the Thaynes of the Paris area could be of Middle Triassic age, since it overlies beds of the Prohungaritan faunal zone, and in its exposed portions, Kummel was unable to find diagnostic fossils.

The point to be made here is that the Thaynes limestone member of the Sublette Ridge area of western Wyoming and of the Hot Springs, Idaho, area, could just as easily correlate with the undated upper part as with the uppermost Early Triassic part of the Thaynes in the Paris, Idaho, area.

The few fossils known from the Alcova limestone are either not diagnostic, or not well enough known, to furnish an age determination as reliable as that which can be achieved with ammonoids. The fossil nothosaur (a marine reptile) found near Alcova, and described by Case (1936), was dated as Triassic by that author, and as Middle Triassic by Zangerl (personal communication to P. O. McGrew, 1953). No other vertebrates are known to have been found in the Alcova limestone.

According to Lee (1927) the invertebrates known from the Alcova consist of the pelecypods Naiadites (?) sp., Bakewellia sp., Pleurophorus (?) sp., Aviculopecten cf., A. curtocardinalis, and one gastropod Natica (?) lelia. Although not indicated, the identifications were made by Girty. The type localities as given by the authors of these species (Hall and Whitfield, 1877) are too generalized to be of more than historic interest in the present discussion. A. curtocardinalis H. & W. (p. 274) was described from, "limestone of the Upper Coal-Measures (Permo-Carboniferous), foothills southeast of Salt Lake City, Wasatch Range, Utah." Natica (?) lelia H. & W. (p. 298) was found, "in a greenish white limestone supposed to be of Triassic age, northwest of Rawlings Station [Rawlins] Wyoming, and on the East Fork of the Duchesne River, Uinta Range, Utah. I do not myself believe this to be Triassic, but it has so been referred by others. -R.P.W."

The only other reference to A. curtocardinalis the writer has found so far is one by

Girty (Veatch, 1907, p. 51-52). This fossil apparently is common throughout the entire Thaynes formation, as it is listed as occurring near the top and also from collections made from the bottom of that formation.

With regard to Natica (?) lelia, it may be a Jurassic form as suggested by Whitfield above, and by Stanton (1899, p. 30); nevertheless there is a form greatly resembling it in the Alcova limestone of the Freezeout Hills. It resembles the illustration of Whitfield's type in every respect except for a slight difference in the rate of expansion of the first two whorls. This is the form, no doubt, to which Girty (in Lee, 1927) had reference. It has been found in the Sinbad limestone member of the Moenkopi (Gilluly and Reeside, 1928, p. 66). To the above fossils reported as occurring both in the Alcova limestone and in units known to be of Early Triassic age, the writer can add the pelecypod Pleurophorus (?) bregeri Girty. Girty (1927, p. 445-446) described this species from a limestone in the Woodside shale at Montpelier Canyon, Idaho. He named two additional species of this genus but indicated that all three were closely related by intermediate forms. Newell and Kummel (1942, p. 951) collected this form from the type locality which they state is in the Claraia zone (earliest Triassic) of the Dinwoody formation as defined by those authors. Although Newell and Kummel (1942) and Kummel (1950) refer to the presence of pelecypods throughout the vertical extent of the Thaynes limestone, they were not described, so that the presence or absence of this species in higher faunal zones is unknown.

In summary, stratigraphic considerations favor an Early or Middle Triassic age for the Alcova limestone. Fossil evidence, though slight, is likewise divided between Middle Triassic age with regard to the nothosaur, and Early Triassic age with regard to the invertebrates. It is possible but unlikely that the Alcova is of Late Triassic age.

Jelm Formation

The upper part of the original Jelm formation (Knight, 1917), is lithologically continuous with the basal Sundance sandstone of Lee (1927), the Entrada (Front Range, Colorado) of Baker, Dane and Reeside (1936) and Heaton (1939), and the Nugget (?) sandstone of Neely (1937). The fact that the upper part of the original Jelm formation (Nugget) is lithologically closely related to the Sundance formation while the rest of the Jelm formation contains redbeds identical to those of the underlying Chugwater formation, and a well developed persistent conglomerate near its top, strongly indicates that the original Jelm formation straddles the Triassic-Jurassic boundary. For these reasons, it is proposed that the name Jelm be applied only to the part which rests disconformably on the Chugwater formation and whose top grades into the overlying Nugget sandstone within a few feet above the "Jelm conglomerate."

The type section of the Jelm formation (restricted) is at Red Mountain where it is 190 feet thick. The Jelm section is more accessible, but less well exposed (Sections VII and VIII, Pl. 5; Tables 1 and 2.).

Lower member of the Jelm formation. - The lower member is defined as that portion of the Jelm formation which disconformably overlies the Chugwater redbeds and is disconformably overlain by the conglomeratic upper member of the Jelm. This member is well exposed at Red Mountain and Jelm, and at Bull Mountain, Colorado. At these sections, it is 142, 164, and 135 feet thick. The disconformity between the Jelm and the underlying Chugwater formation is clearly visible at the Bull Mountain section (Pl. 4, B). The basal beds of the Jelm fill channels in the underlying Chugwater in the same way the Wingate sandstone fills the channels in the Chinle formation (Gilluly and Reeside, 1928, Pl. 17, A).

The lower member of the Jelm formation can be confused only with the Nugget sandstone, but can be distinguished from it by the following lithologic characteristics:

1) Presence of chlorite, muscovite and biotite flakes (absent in the Nugget).
2) Presence of clay shale and claystone redbeds (absent in the Nugget).
3) Presence of beautifully ripple-marked, hard, highly calcareous gray-green siltstone ledge-makers (absent in the Nugget).

The lower member of the Jelm formation of the Como Bluff-Flat Top anticline sections contains a calcite and chert bed one-fourth to one-half inch thick, whose upper surface develops unusal pink and white concentric chert rosettes up to one inch in diameter. This key horizon is 60 feet below the "Jelm conglomerate" at Como Bluff, and 51 feet below the same conglomerate at Flat Top anticline. It must persist to the southwest inasmuch as Dr. S. H. Knight (1948) showed the writer samples of similar pink and white chert rosettes which he collected from the Jelm of the Elk Mountain area, 30 miles southwest of Como Bluff.

Both the Nugget sandstone and the lower member of the Jelm contain large rounded varicolored quartz-grains. In the type area, the lower part of the Jelm formation is orange to reddish pink while the Nugget sandstone is bleached (?) cream-white to buff as often as it is pink. Where the Red Mountain section was measured the Nugget sandstone is pink and differs in color from the lower Jelm only in that it lacks the orange tint of the Jelm sandstone beds. However, if one traces the Nugget southwest from this locality he will round a covered spur and come upon a good exposure of the Nugget which is entirely creamy white to buff in color, less than one-fourth mile from the Red Mountain section.

The lower member of the Jelm formation extends to the northernmost measured section of the Freezeout Hills. There the sandstone is less conspicuous and is either gray-white or mottled pink and gray. The redbeds and limy siltstones are thicker and more numerous, and the member rests with apparent conformity on the Alcova limestone.

Upper member of the Jelm formation. - The upper member of the Jelm formation is designated as the conglomeratic part of the original Jelm formation and an associated sequence of gray very fine to coarse-grained lime-cemented cross-bedded sandstones that overlie the lower Jelm and underlie the Nugget sandstone.

This member is of nearly uniform lithology and thickness throughout the area studied. Its thickness varies from 5 feet to 50 feet in the north and from 24 feet to 49 feet in the south.

It is nearly always gray, probably because it contains the conglomeratic zone which offers easy access to "bleaching" agents. Everywhere it is very fine grained at the top and grades within a few feet into the overlying Nugget; it is medium to coarse grained at the base or near the conglomerate. The upper Jelm is well cemented, cross-bedded, and makes slabby ledges or prominent ridges. It contains an abundance of chlorite, muscovite and biotite flakes. The quartz grains are subangular at the base and subrounded to rounded at the top.

The conglomerate varies in thickness from 4 inches to 1 foot. The largest boulder observed did not exceed one foot in length. The matrix is a mixture of calcareous green clay, yellow-green siltstone, and fine to very coarse grained sandstone. Biotite and chlorite flakes are abundant throughout the matrix, as are large subangular varicolored quartz grains. The subrounded to well rounded pebbles, cobbles, and boulders consist of yellow-gray sandstone and siltstone, red-brown and green claystone, gray sandy limestone, white bone fragments and lime- and silica-replaced wood fragments.

In the following discussion the name Jelm is used in the restricted sense except where otherwise noted. As originally defined the Jelm formation included more than one formation and should be considered a group, apparently equivalent to the Glen Canyon group. Like the latter, the two main sandstone units of the original Jelm locally are deceptively similar. This is especially true of the rocks in the type Jelm area.

The correlation of the Jelm formation with similar rocks elsewhere is uncertain. It is very likely that those authors who correlate the Jelm formation with the Popo Agie member of the Chugwater in west-central Wyoming are correct in so doing. These two units have much in common. Both overlie the Alcova limestone, where that unit is present; both contain massive cross-bedded orange-colored sandstone; both are conglomeratic; both contain redbeds; both contain vertebrate remains and fossil wood fragments; and both underlie the Nugget sandstone. The presence of the Jelm formation as far north as the

Freezeout Hills is established in this paper. No beds characteristic of the Jelm formation are present in the Glendo-Hartville areas (Love et al., 1949; Denson and Botinelly, 1949) so that the presence of the formation farther north is questionable.

As mentioned previously both Lee (1927) and Heaton (1939) recognized, in effect, the presence of the "Jelm group" for a considerable distance southward along the Colorado Front Range. Heaton called the upper sandstone unit of the "Jelm group" the Entrada, whereas Lee called it the basal Sundance sandstone.

The lower Jelm has many features in common with the Wingate. Both contain orange-red cliff-makers, both contain redbeds, and both underlie conglomeratic beds (Baker, Dane and Reeside, 1936, pp. 12, 14).

The massive cross-bedded sandstone in the lower part of the Jelm formation may be of eolian origin but the redbed facies is of subaqueous origin, if not marine, as shown by the ripple-marked highly calcareous siltstone beds. The conglomeratic member of the Jelm formation has the characteristics of a fluviatile deposit.

As has been implied above, the main body of the Jelm may be of Late Triassic age, while the overlying conglomeratic portion is either Triassic or Early Jurassic as may be inferred from the gradational nature of its contact with the overlying Nugget sandstone.

Nugget Sandstone

In the Laramie Basin area the term Nugget sandstone is here applied to those rocks overlying the Jelm formation and underlying the Sundance formation. The sandstone grades, within a few feet, downward into the upper conglomeratic member of the Jelm formation and is overlain by the Canyon Springs sandstone member of the Sundance formation with apparent conformity.

The composition and external aspect of the Nugget sandstone are remarkably uniform. The formation consists of very fine grained limy sandstone with scattered well rounded medium to coarse quartz and chert grains. These grains are colored black, purple, brown, rose, white and transluscent gray to transparent. In general, the smaller grains are lighter colored and better rounded than the larger grains. Where the beds have a low dip, the Nugget sandstone crops out in a vertical cliff. With higher dips the Nugget sandstone commonly crops out in a valley bounded on one side by the ridge and dip-slope made by the Jelm conglomerate and on the other by the thin-bedded slabby sandstone ledges in the Sundance formation.

The sandstone is highly porous, soft, friable, massive, and conspicuously cross-bedded on a large scale. It persists throughout the entire Laramie Basin and, in the author's opinion, extends as far north as the vicinity of Douglas, Wyoming, and southward at least as far as Owl Canyon, Colorado. In these localities it constitutes the bulk of Lee's basal Sundance sandstone. The eastern limit of the Nugget sandstone is unknown, but it may well be part of the basal Jurassic sequence which thickens in the subsurface southeastward from the Glendo area (Love, et al., 1949).

Since the sandstone in question is overlapped by the Sundance formation and is distinguished from the upper member of the Jelm by a gradational but significant lithologic change, there is no known lithologic unit it could correlate with other than Nugget sandstone. At their type sections, the Nugget and Navajo sandstones are overlain by formations containing fossiliferous marine Jurassic rocks. The author believes that the Nugget sandstone of this paper is lithologically continuous with the Nugget sandstone of central and western Wyoming. It is believed to be the equivalent of the basal Sundance sandstone of the Front Range of northeastern Colorado (Lee, 1927) and of the Entrada of the same region as defined by Heaton (1939, 1950). The writer suggests that it is the Navajo sandstone and not the Entrada that persists eastward from the San Rafael Swell into the north-central part of Colorado.

The basal sandstone of the Jurassic sequence in the Glendo-Hartville areas (Love

et al., 1949; Denson and Botinelly, 1949) consists of an upper fossiliferous part called the "oolitic sandstone," a middle fossiliferous part called the "Cephalopod sandstone" and a lower unfossiliferous part that resembles the Nugget sandstone. The fossils of the "oolitic" and "Cephalopod" sandstones are of Late Jurassic age (Imlay, 1953). The writer believes the underlying unfossiliferous unit to be equivalent to the Nugget of this paper.

Turning back to the Front Range of Colorado, the writer has examined the Owl Canyon section, described and illustrated by Lee (1927) and Heaton (1939), enough to satisfy himself that member A and the Canyon Springs sandstone of the Sundance formation, and the Nugget and Jelm formations are present. As Heaton notes, there is little difference between the units in this section and those in the Bull Mountain, Colorado, section, except that the Jelm conglomerate is absent, as are the reddish claystone and shale beds in the upper part of the lower Jelm.

The recognition of the Nugget sandstone in the Front Range of Colorado, where it has been called basal Sundance sandstone by Lee, and Entrada by Baker, Dane and Reeside, by Heaton, and by a number of other authors, would suggest that in many places farther west and south, what has been called the Entrada is the Nugget or Navajo sandstone. This is quite possible where there are no fossiliferous Carmel equivalents separating the Entrada from the Navajo. That the Navajo can be mistaken for the Entrada is made clear by the original description of the Entrada in the type locality (Gilluly and Reeside, 1928, p. 76):

> Where it is clean and well sorted it stands in steep cliffs with rounded shoulders and in huge domes, such as are so characteristic of the Navajo sandstone.

The writer believes that the relationship of the San Rafael group to the Glen Canyon may be the same as that of the Sundance formation to the Nugget and Jelm formations of the Laramie Basin; that just as the Sundance overlaps the Nugget from north to south, so the San Rafael group laps onto the Navajo from west to east. The Carmel, Entrada, Curtis sequence is similar to the Canyon Springs sandstone - Stockade Beaver shale - Hulett sandstone; the Lak member; and the Redwater shale member of the Sundance formation. At its type section the Entrada sandstone "is separated from the overlying Curtis formation by a surface of erosional unconformity and rests on the Carmel formation with apparent conformity." (Gilluly and Reeside, 1928, p. 76). The Carmel formation is fossiliferous, and although final decision must await further studies of its faunas, the published faunal lists indicate an early Callovian age for the Carmel and, by inference, a late Callovian age for the Entrada. Correlation of the Carmel and Entrada formations with similar units in the Uinta Mountains affords indirect evidence as to the age of these formations. Nearly all earlier workers in this area considered the Preuss sandstone of the Uintas to correlate with the Entrada of the San Rafael Swell (Bartram, 1930; Baker, Dane and Reeside, 1936; Heaton, 1939; Thomas and Krueger, 1946). Imlay favors this correlation (1950, p. 41) and in addition finds that the underlying Twin Creek formation is of Late Jurassic age in the upper part and of Middle Jurassic age in the lower part. The Twin Creek probably correlates with the Carmel formation. Since in passing southward from southwestern Wyoming toward the Uintas the Twin Creek formation loses some of its older units (Imlay, 1950, p. 39), a continuation of this trend southward would imply that the Carmel formation is of Callovian age, if not in its entirety, then certainly in its upper part. It does not seem plausible for the trend to reverse itself to the extent that the Carmel could be entirely of Middle Jurassic age.

The fossil evidence, though incomplete, in conjunction with stratigraphic considerations make it appear almost certain that at least the upper part of the Carmel is of early Callovian age and that the overlying Entrada is of late Callovian age. Since the Nugget sandstone in the northeast Freezeout Hills (Section I) underlies rocks of early Callovian age, whereas the Entrada overlies rocks of early Callovian age, the possibility that the Nugget of this paper could be equivalent to the Entrada sandstone appears to be quite remote. The unit which does satisfy all requirements for correlation with the Entrada is the Lak member of the Sundance formation. The Lak, like the Entrada, overlies beds of early Callovian age. The above tends to corroborate the opinion long held by Imlay (1947, 1948, 1950) that the type Entrada correlates with the type Lak.

As stated previously, the Nugget sandstone has been traced from the Freezeout Hills southward to Owl Canyon, in the Front Range of Colorado. Lee (1927) traced this same unit (his basal Sundance sandstone) even farther south. Heaton (1939) traced it (his Entrada sandstone) from Bull Mountain (Section X) into the type Wingate area. The possibility therefore must be considered that it is the Navajo and not the Entrada that persists eastward from the San Rafael Swell to the Colorado Front Range. The author has examined briefly the section near Dotsero, Colorado, and recognized it as consisting from bottom to top of an orange-pink sandstone identical to the lower Jelm, overlain by a yellow-buff sandstone identical to his Nugget, which is overlain by a thin plane-bedded unit identical to the Canyon Springs sandstone. The fossiliferous sequence overlying the Canyon Springs sandstone yielded fragments of small Camptonectes which may prove identifiable when compared with type specimens. No Pachyteuthis were found. The fossiliferous rocks contain abundant ooliths identical in appearance to those of the "lower Sundance" of Wyoming and reminded the writer of the oolitic sandstone beds of member B of this paper.

The origin of the Nugget sandstone of the Laramie Basin may be subaqueous and/or eolian. It grades down into the "trashy" Jelm conglomerate of fluviatile origin and gives way to sandstone of marine origin at the top. Although all three units are sandstone, the Nugget has characteristics quite different from both the others. It lacks all the usual lacustrine or marine characteristics such as ripple-marks, plane-bedding, glauconite, fossils, etc.

Sundance Formation

The Sundance formation of eastern Wyoming is thin but complex in its make-up. The type Sundance and the remnants of the Gypsum Spring formation comprise some 400 feet of beds in the Black Hills, and span a length of time represented by rocks over 2,000 feet thick in western Wyoming and adjacent areas. The individual members of the Sundance are persistent and some are recognizable throughout large areas, but in eastern Wyoming are too thin to map on the scales presently in general use. The subdivision of the Sundance formation is valuable from a stratigraphic viewpoint. It is only by careful tracing of the individual units that the possibilities of stratigraphic oil traps will be realized. The practice of lumping units for convenience in mapping and other purposes can be of little use in outlining specific areas favorable for stratigraphic traps. The last calls for the optimum discrimination of quite thin units, achievable only by careful detailed examination of lithology and careful notations of the faunas of each bed.

Canyon Springs sandstone member. - The Canyon Springs sandstone probably is present throughout the entire area, although it is definitely recognizable only in the northern group of sections (I through V). It varies in thickness from 6 to 12 feet and is lithologically similar to the Nugget sandstone. It differs from the Nugget in that it is plane-bedded rather than cross-bedded, it contains more limonitic material than the Nugget, and locally, as in the West Flat Top anticline (Section IV), it is ripple-marked and the limonitic material is bedded rather than nodular. The Canyon Springs sandstone was not recognized in the sections south of Como Bluff (Section V) even where the exposures are good, as at Red Mountain and Bull Mountain, but nevertheless it probably is present because the Canyon Springs sandstone seemingly is present to the east and west of the Bull Mountain section, at Boxelder Canyon and Dotsero, Colorado. The Boxelder section is described and illustrated by Lee (1927, p. 39; Pls. 24, 26) and the Dotsero section is described and illustrated by Baker, Dane and Reeside (1936, pp. 19, 28; Pl. 20). The Jelm-Nugget-Canyon Springs sequence is apparently identical in both these localities except for thickness. The Canyon Springs sandstone in these sections is characterized by manganese dioxide dendritic growths which are not found in the underlying Nugget. No fossils were found in the Canyon Springs sandstone, but in the Northeast Freezeout Hills (Section I) it is overlain by the Stockade Beaver shale which contains fossils of early Callovian age, and in the vicinity of the Young Ranch about 11 miles to the southwest Roger G. Hubbell (1954, p. 30) reports a fossiliferous limestone beneath the Canyon Springs sandstone and above the Nugget. The author examined specimens of this fossiliferous limestone and although the fossils are not well preserved and are not especially diagnostic, the Camptonectes and brittle star fragments are similar to those in bed 34 of the Northeast Freezeout Hills section and thus presumably also of early Callovian age.

The Canyon Springs sandstone of the Freezeout Hills area is here correlated with the "Cephalopod sandstone" of the Glendo area (Love et al., 1949), which contains fossils of early Callovian age, and with the type Canyon Springs sandstone of the Black Hills, also of early Callovian age (Imlay, 1947). Although the Canyon Springs is of early Callovian age in the areas discussed thus far, it appears probable that it becomes progressively younger southward. In the East Freezeout Hills section (II) it is separated from the Hulett sandstone by what appears to be the wedge-edge of the Stockade Beaver shale; in the Flat Top anticline and Como Bluff sections (III, IV, V) it is overlain by buff sandstone beds equivalent to the Lak member; in the Centennial and Jelm sections (VI, VII) the Canyon Springs sandstone is probably present but concealed and probably directly underlies member B. Farther south and east it is overlain by member A but separated from it by an erosion surface. In brief, it appears that the Canyon Springs sandstone marks the transgression of the Callovian sea upon the Nugget sandstone and that it ranges in age from early Callovian in the northern part of the Freezeout Hills to late Callovian along the southwest margin of the Laramie Basin, in the vicinity of Jelm, Wyoming. It is unlikely that the Canyon Springs is younger than late Callovian anywhere in this area. The last known deposits of the late Callovian sea were beds of member B which are separated from the overlying Redwater shale by a relatively small hiatus that is nevertheless widespread geographically. Still farther east and south the Canyon Springs sandstone is overlain by member A in the Boxelder Canyon area. There is no striking evidence of disconformity, but the hiatus between the Canyon Springs sandstone and member A, in this area, spans from early Callovian to late early Oxfordian time at least, and perhaps all of Oxfordian time.

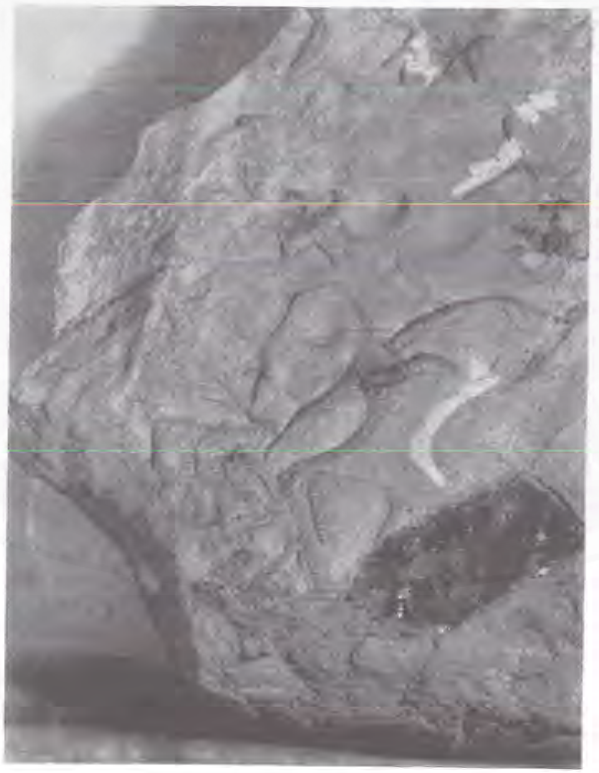

Figure 2. - Fossil brittle stars, Amphiura n. sp., collected from the Stockade Beaver shale of the northeast Freezeout Hills.

The Canyon Springs sandstone at the Dotsero locality is overlain by oolitic rocks containing marine fossils of probable Callovian age. This rock type is similar to the oolitic beds at the base of member B of the Como Bluff section (V, bed 14 especially) and has never been observed in younger beds by the author. The oolitic beds locally encountered in the Redwater shale member contain much larger ooliths and are quite different in appearance, (especially in the Como Bluff area and in the Ring Mountain section (IX). The fossils found in the Dotsero locality have not yet been studied but since they consist for the main part of small rather than large Camptonectes, and contain no trace of Pachyteuthis so prevalent in the Redwater shale, it appears almost certain that these beds are of Callovian age; that they are a "lower Sundance" rather than an "upper Sundance" equivalent. The writer suspects that this unit will eventually prove to be of late Callovian age and equivalent to member B of the Sundance formation.

Stockade Beaver shale. - This member is definitely present only in the Northeast Freezeout Hills section where it consists of 35 feet of interbedded shale, limestone and sandstone in beds 1/2 foot to 1 1/2 feet thick. The overall color is gray-green and the unit forms a ledgy slope. The member is highly fossiliferous. Float near the base yielded good specimens of the brittle star Amphiura n. sp.* The slab (Fig. 2) probably came from the top one foot, which also yielded specimens of Meleagrinella orbiculata (Whitfield), 1880 (equals Pseudomonotis (Eumicrotis) orbiculata Whitfield, 1880). This species is one of two cotypes of Whitfield's genus Meleagrinella#, and it was found only in this unit. It is larger than Meleagrinella curta (Hall), 1852, the other cotype, which seems to be present throughout most of the Sundance formation. The brittle star reported from the Black Hills, Ophiocten (?) bellefourchensis, was collected by Hovey from "a sandy limestone occurring in Belle Fourche Valley, Wyoming" (Whitfield and Hovey, 1906, p. 391). I feel certain it came from the Hulett sandstone or a sandy limestone bed in the Stockade Beaver shale. Brittle star fragments, as well as Meleagrinella orbiculata, were collected in the Glendo-Hartville areas from beds above the "oolitic sandstone" and below the redbeds. This unit was called the Eumicrotis zone (Love et al., 1949) and correlated, in effect, with the Stockade Beaver shale-Hulett sandstone sequence of the Black Hills. The Meleagrinella orbiculata beds of this paper are considered lithologically and faunally equivalent to the Eumicrotis zone of the Glendo-Hartville areas and to the Stockade Beaver shale of the Black Hills. The 10-foot sandstone bed at the base of the Stockade Beaver shale of the Northeast Freezeout Hills section is here correlated with the "oolitic sandstone" of the Glendo area and with a part of the Stockade Beaver shale of the Black Hills.

Hulett sandstone. - This unit was recognized in the two Freezeout Hills sections but is absent farther south. It consists of sandstone 13 to 18 feet thick that is green-white to yellow-white, very fine to fine-grained, limy and ripple-marked. Fossils are rare so that its correlation with the Hulett sandstone of the type section is based on its position above the Stockade Beaver shale and below the Lak redbeds. At the type section it is beautifully ripple-marked and likewise sparsely fossiliferous.

The Canyon Springs sandstone, Stockade Beaver shale and Hulett sandstone members are considered Early Callovian in age and correspond almost exactly to the Rierdon formation of Montana (Imlay, 1947).

Lithologic and faunal equivalents of these beds have been traced throughout most of Wyoming, Montana and parts of Idaho and Utah by Imlay (1947 et seq.).

Lak member. - This is a redbed unit present in the Freezeout Hills, and probably as far south as Como Bluff, but not recognized south of Como Bluff.

In the Northeast Freezeout Hills section it consists of 32 feet of orange-red very

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* Identified by Dr. Charles T. Berry, No. 1 Harvey Road, Stonington, Conn. This form, which will be described by Dr. Berry, was tentatively referred to Ophiocten (?) bellefourchensis Whitfield and Hovey, 1906 by Pipiringos (1953, p. 35).

American paleontologists overlooked the genus Meleagrinella Whitfield, 1885, until the British paleontologist L. R. Cox (1941) called attention to its validity, 56 years later.

fine to fine-grained limy sandstone. It contains a sandstone bed one foot thick that is greenish white and makes a weak ledge 12 feet below the top. The basal 5 to 7 feet is green-white. The lithology is uniform from top to bottom, white zones being merely "bleached." It is separated from the overlying Redwater shale, containing the characteristic Cardioceras and Pachyteuthis zones, by 13 feet of sandstone and siltstone, green-white in color except for the middle 2-foot portion which is red-brown. This unit, separating the Lak member from the Redwater shale member, comprises member B of this paper, and will be discussed later, but is mentioned here because of its importance in defining the upper limits of the Lak member.

In the East Freezeout Hills section the Lak is 33 feet thick and has developed a very clayey matrix. The pink-red color is confined to the upper 11 feet, while the underlying "bleached" portion contains a very few grains of dark green glauconite(?). The glauconite of the "lower Sundance," is much smaller in grain-size than the glauconite of the "upper Sundance," and usually lighter in color. The Lak rests on the Hulett sandstone as in the northern section and is overlain by member B which has increased in thickness from 13 feet to 32 feet, with a corresponding thickening of its central redbed portion from 2 to 18 feet, but not at the expense of the underlying Lak member. This indicates that the Lak member is separable from member B and is not a facies of it.

The change in color of the Lak from red in the north to green-white in the south may be due to a change in environment of deposition (facies change) or to more extensive "bleaching." The presence of glauconite(?) tends to favor the first possibility. In the Flat Top anticline and Como Bluff sections, a sandstone unit underlying member B and overlying the Nugget sandstone, is interpreted to be the wedge-edge of the Lak which has completely lost its red color.

On the basis of lithology and stratigraphic position (above beds of early Callovian age and below the Cardioceras zone of early Oxfordian age) it is correlated with the "lower Sundance" redbed unit of the Glendo-Hartville areas and with the Lak member of the type Sundance of the Black Hills, which Imlay (1947) correlates with the Entrada sandstone.

It is to be noted that this stratigraphic position is identical to that of the type Entrada, which is underlain by the marine Carmel (Callovian and older) and overlain by the Curtis (Oxfordian). The Nugget of this paper underlies beds of lower Callovian age and cannot be the Entrada as suggested by some authors. It is the Lak which is more likely equivalent to the Entrada.

The Lak member is probably marine, even where it consists of redbeds.

Member B. - The presence of a thin unit of normal marine sediments between Lak and Redwater shale equivalents has been noted in many places by several authors. It is known to be present in the Glendo-Hartville areas, in exposures of the Sundance southwest of Douglas, Wyoming, and Imlay noted the presence of reddish beds at the base of his Redwater shale member. The reddish color in the base of the Redwater shale was presumably derived from the underlying Lak (Imlay, 1947), but might be the wedge-edge of member B.

Member B is persistent in the sections examined, and locally, as in the Como Bluff and Flat Top sections, becomes prominent and makes up most of the "lower Sundance" (Table 2 and Pl. 5).

The lithology of member B is similar to that of the Stockade Beaver shale, but differs from it in containing numerous prominent slabby ripple-marked ledge-forming sandstones and a thin but persistent redbed unit near the middle. Faunally it is characterized by Trigonia sturgisensis Whitfield and Hovey, 1906, sometimes misidentified as Trigonia quadrangularis Hall and Whitfield, 1877. T. sturgisensis was based on specimens collected from localities in the Black Hills. No information was given on stratigraphic position except in the case of one specimen collected 75 feet above the base of the Jurassic, and about 50 feet above the bed in which another specimen was found (p. 395).

This would indicate that the forms figured on Plate 48, figs. 1, 2, and 3, (Whitfield

and Hovey, 1906) which I believe to be conspecific with the forms collected from member B, came from somewhere in the Stockade Beaver shale member.

At any rate, T. sturgisensis has not been reported from the Redwater shale member, and in the Laramie Basin was found only in member B. It may be present in lower beds, but the fragments of Trigonia found there were too poorly preserved for identification. The member B Trigonia is probably in need of a new name inasmuch as the first specimens of T. sturgisensis mentioned and figured by Whitfield (p. 395; Pl. 47 and Pl. 48, fig. 7) are much larger and different in shape from the others (Pl. 48, figs. 1, 2, 3).

Como Bluff is the type locality of Trigonia quadrangularis Hall and Whitfield, 1877. The original figure of the type is poor and the specimen itself is incomplete. The stratigraphic position is unknown:

> In light colored somewhat shaly, limestones of Jurassic age, near Como, Laramie Plains, Wyoming, associated with Pentacrinites asteriscus M and H and other Jurassic species. Collected by Arnold Hague, esq.

The author has made extensive collections from Como Bluff and can state that the Redwater shale is profusely fossiliferous while underlying beds are sparsely fossiliferous, most of the fossils being fragmentary. The only Trigonia found there by the writer came from the basal beds of the Redwater shale. They were small forms 1/2-inch in height or less, which compare favorably with the length given for the type of T. quadrangularis (1/2-inch), whereas T. sturgisensis is a larger form closer to one inch in height. The type of T. quadrangularis probably came from the Redwater shale and is different from the larger Trigonia "quadrangularis" reported from the "lower Sundance" and equivalents in the Wind River region and southwest Wyoming. The best locality for collections of Trigonia sturgisensis(?) is from the upper part of member B at section III of Flat Top anticline where they are common.

Member B is further characterized by peculiar flattened worm track casts marked with a longitudinal furrow down the center. Both T. sturgisensis(?) and these peculiar worm track casts are found at the Centennial Valley section, but farther south only the furrowed worm track casts are present. At Centennial, member B has thinned to about 26 feet, but persists southward to Bull Mountain, where it is 16 feet thick.

Member B appears to be latest Callovian in age. Its fauna is much different from that of the overlying Redwater shale member, and it overlies the Lak member which Imlay (1947 et seq.) believes to be of late Callovian age.

Perhaps further examination of this interval will yield diagnostic ammonites. In southeastern Wyoming, where the Lak is present, although there may be a lithologic and faunal break between member B and the Lak, these two are closely related, while member B and the overlying Redwater shale member are distinct both faunally and lithologically. For these reasons member B is assigned to the "lower Sundance" group of beds of Callovian age rather than with the overlying Redwater shale.

Redwater shale member. - This unit is characterized by the first appearance of large grains of glauconite. In many areas there is a fairly thick massive to thick-bedded sandstone at its base, but this basal sandstone is lenticular. It is not present in the Laramie Basin in the sections examined. This unit is further characterized by sandy limestone coquinas and numerous sublithographic limestone concretions which the writer has never seen in older members of the Sundance formation.

The Redwater shale for a long time was considered by many people to constitute the entire Sundance formation of southeastern Wyoming. It is profusely fossiliferous, and all the early workers overlooked or ignored the sparsely fossiliferous underlying members. Their collections naturally represented a single faunal and lithologic unit. Schuchert (1910) named the Logan sea after Professor Logan who was the first to systematically study the fossils of the marine Jurassic of the Freezeout Hills and of Como Bluff. All the fossils which Logan (1900) illustrated and described that are now known to have diagnostic value

are Redwater shale forms, such as "Belemnites" sp. and Astarte packardi White, 1883, which was described from "Jurassic strata near Como Station, on the Union Pacific Railroad, Wyoming," where it was discovered by Prof. A. S. Packard, Jr. He found it associated with "Eumicrotis curta, Belemnites densus and other well known Jurassic forms" (p. 149). These were renamed Meleagrinella curta by Whitfield (1884), and Pachyteuthis "densus" by Crickmay (1936). The author is convinced that A. packardi White, 1883, is the same as A. dacotensis Whitfield and Hovey, 1906. Logan described also "Avicula" mucronata Meek, 1865 (renamed Oxytoma wyomingensis by Stanton, 1899) and the index fossil Cardioceras cordiforme (Meek and Hayden), 1858. The Logan sea, therefore, is not the "Sundance sea", but is the sea in which only the rocks of the Redwater shale member were deposited. The Redwater shale member is familiar to all geologists who have even a slight acquaintance with the Sundance formation. Its lithologies are well known; its cigar-shaped Pachyteuthis "densus" is an index fossil familiar to all. In eastern Wyoming, this fossil is a reliable guide to the Redwater shale. Elsewhere it has been reported as occuring in beds well below the Cardioceras zone, but the writer suspects that Pachyteuthis did not appear in the Jurassic sea of the Western Interior much earlier than did Cardioceras.

The upper part of the Redwater shale member has not yielded diagnostic fossils and it is uncertain whether its rocks were deposited entirely in Oxfordian time or whether deposition continued into Kimmeridgian time.

The author believes the Redwater shale is entirely early Oxfordian because there is no evidence of interrupted deposition within the sequence and the only ammonites found in it are of early Oxfordian age. There is no abrupt change in lithology until the top is reached where it is sharply overlain by member A of the Sundance.

Member A. - Overlying the Redwater shale of southeastern Wyoming is a thin persistent sandstone unit herein designated member A of the Sundance formation, that, in the Laramie Basin area, bevels from north to south all the underlying members except the Canyon Springs. It ranges from 4 to 30 feet and averages about 12 feet in thickness; it is usually orange-yellow to yellow-tan in color; it always makes a thin-bedded, slabby ripple-marked ledge, and locally contains the fossils Pachyteuthis sp., Ostrea sp., Meleagrinella sp., and Pentacrinus sp.

The lithology is distinctive. Locally this unit may contain shale, siltstone and limestone partings similar to the beds in the Redwater shale, as in the East Freezeout Hills (Section II), the type locality for this member, but usually it consists entirely of lime- or calcite-cemented very fine to very coarse grained sandstone. Where the lime matrix is chalky, it surrounds the clear subrounded quartz grains in such a manner that the rock suggests a mass of tapioca. In the Glendo-Hartville areas, and in the Black Hills, this appearance has been termed "pseudo-oolitic." Where the matrix is composed of calcite, fresh fractured surfaces have a sparkling sheen. Locally this unit contains flesh-colored ooliths and scattered grains of green clayey material that may be altered glauconite. In places the ripple-marked surfaces are mud-cracked and the fissures filled with blue-white chalcedony. Silica in the form of chert, chalcedony, or clear quartz, is present in this unit wherever it was examined by the author, suggesting that it was leached from siliceous (volcanic?) beds in the overlying Morrison, carried downward by groundwater and deposited in the permeable sandstone (member A) resting on the impermeable shales of the underlying Redwater shale or member B of the Sundance.

As stated earlier in this paper, the author has recognized this unit as far south as Owl Canyon, Colorado, where it rests on the Canyon Springs sandstone. In this general area it contains thin beds of variegated claystone and clayey sandstone suggesting intertonguing with the Morrison formation.

In the Glendo area there is "10 to 25 feet of yellowish-buff porous nonglauconitic thin-bedded pseudo-oolitic sandstone . . ." (Love, et al., 1949) which the author correlates with member A. Likewise in the Hartville area, Denson and Botinelly (1949) report the presence of a sandstone bed at the top of the Sundance 10 to 25 feet thick which is "yellowish-buff, porous, nonglauconitic, thin-bedded, pseudo-oolitic and contains frag-

mentary gastropods and pelecypods of possible marine origin. It is remarkably persistent and was deposited on a channeled surface cut in the underlying shale. Directly above this sandstone are gray fresh-water limestones containing Chara seeds and ostracodes typical of the Morrison formation."

Mention has previously been made of Darton's remarks (1899) concerning the possibility that this unit in the Black Hills might be an Unkpapa sandstone equivalent. Imlay in 1947 expressed the same opinion, and in the section chosen as standard for the Sundance formation he assigned it to the Morrison formation, but in some of his described sections included it in the Redwater shale.

Because of the disconformable relationship of this member to the underlying Sundance members, i.e., resting on the Redwater shale in the Freezeout Hills-Centennial, Wyoming sections, on member B in the Jelm, Wyoming, -Bull Mountain, Colorado sections, and on the Canyon Springs sandstone at Owl Canyon, Colorado, it is obviously distinct from the Sundance formation. However, it is also distinct from the Morrison formation in that it persists for hundreds of miles while the overlying beds vary from lenticular dune-like sandstone to fresh water limestone and claystone beds. The fossils are proof of a marine, or at least brackish water environment of deposition, different again from the terrestrial environment in which the Morrison strata were deposited. It seems more logical to regard this member as having been deposited in Kimmeridgian time after a period of erosion which removed the late Oxfordian beds, rather than having been deposited in late Oxfordian time with a regional hiatus within the Oxfordian. The author suggests for convenience that this member be considered as a member of the Sundance formation rather than as a separate formation or a member of the terrestrial Morrison formation. Member A is lithologically similar to the Summerville formation, has the same stratigraphic position and probably correlates with it in part.

SUMMARY AND CONCLUSIONS

Most of the evidence concerning the age and correlation of the Alcova limestone indicates that it may correlate with the part of the Thaynes limestone of western Wyoming that is of Early Triassic age; but it may correlate with the uppermost beds of the Thaynes limestone which are undated, and may be of Middle Triassic age. It is unlikely that the Alcova is of Late Triassic age.

The Jelm formation of southeastern Wyoming as originally defined, is divisible into three parts roughly analogous to those comprising the Glen Canyon group. The "basal Sundance sandstone" unit referred to as the Entrada by some authors is believed to be the correlative of the upper part of the type Nugget and of the Navajo formation, and comprises the upper part of the original Jelm formation. The name Jelm is retained for the lower part characterized by a fossiliferous limestone pebble conglomerate near the top and massive cross-bedded orange and white sandstone intercalated with redbeds in the lower part. The Jelm overlies the Chugwater disconformably and underlies the Nugget conformably.

The lower part of the Jelm (restricted) consists of a sandstone facies of eolian and/or subaqueous origin and a typical redbeds facies of marine(?) origin. North of the type Jelm area the redbeds facies becomes more conspicuous, and the sandstone beds lose their prominent eolian characteristics.

The Sundance formation of southeastern Wyoming is comprised of seven members, two of which are new. From bottom to top they are the Canyon Springs sandstone, Stockade Beaver shale, Hulett sandstone, Lak member, member B, Redwater shale member, and member A. The formation thins from north to south. The Sundance formation overlaps the Nugget sandstone from north to south.

The hiatus at the base of the Redwater shale is inconspicuous, and appears to be of short duration but of wide geographic extent. The original limits of the Redwater shale are unknown as it is bevelled by the overlying member A. It pinches out between Cen-

tennial and Jelm.

Member A is present throughout much of eastern Wyoming. It extends from the Black Hills south as far as Owl Canyon, Colorado. It is separated from the underlying Redwater shale by a hiatus that represents only later Oxfordian time in the north, but all of Oxfordian and most of Callovian time in the southern part of the area.

The Sundance formation is complex enough to be considered a group in the same sense that the Twin Creek limestone and the Ellis formation are groups. Neely (1937) coined the phrases "Upper Sundance" and "Lower Sundance", but his usage of those terms in eastern Wyoming does not coincide with his usage in west central Wyoming. Neely conceived of the "Upper Sundance" as being separated from the "Lower Sundance" by a major erosional unconformity between the redbeds of the "Lower Sundance" and the overlying members of the Sundance. This hiatus coincides with the Callovian-Oxfordian boundary as defined by Imlay (1947) in the Black Hills and as defined by this paper for the Laramie Basin area. But the redbeds of Neely's "Lower Sundance" as described and illustrated in the case of the Circle Ranch-Bull Lake Canyon-Lander sections are considerably below the true stratigraphic position of the Lak member. In the course of his work on the Mill Creek faunule of the Gypsum Spring formation, the author visited briefly the Bull Lake Canyon section and measured a section of the Gypsum Spring-Lower Sundance sequence. He was unable to match his section with Neely's bed for bed, but was fortunate enough to find a well preserved echinoid in an oolite one foot thick at the top of the redbed sequence. The echinoid was identified by the author as Stomechinus magnicornicolus Cooke (1947), and the identification was verified by C. W. Cooke (Written communication, 1953). The range of this fossil is not known. The types came from beds in the northeast corner of the Bighorn Basin from beds that Imlay considers Gypsum Spring formation equivalents. Whether this fossil ranges into beds of Callovian age or not, it is clear that the redbeds of Neely's "Lower Sundance" are not in any way equivalent to the Lak member of the Black Hills, and that his hiatus in the Bull Lake Canyon area is within beds of early Callovian age or between beds of Callovian age and older beds. Furthermore, Neely's Gryphaea zone is probably of Callovian age inasmuch as Imlay reports that the first appearance of Gryphaea nebrascensis, Meek (1865) in abundance, coincides in other areas with the first appearance of the early Callovian ammonite Gowericeras subitum Imlay.

In view of the above, the author recommends the "Upper Sundance" be restricted to beds of Oxfordian age, or Oxfordian and younger marine Jurassic beds if member A of this paper comes into general acceptance as a member of the Sundance formation. This subdivision should be named and given formational status equal to that of the Swift formation of Montana (Cobban, 1945). The "Lower Sundance" should be used as Neely used it in the Black Hills and in the Freezeout Hills, and as Love, Denson, et al. used it in the Glendo-Hartville areas. This would mean that Neely's Gryphaea zone of the Bull Lake Canyon area should be taken out of the "Upper Sundance" and placed in the "Lower Sundance." If future paleontologic and stratigraphic studies in that area show that there is a lithologic break coinciding with the Middle Jurassic-Upper Jurassic boundary, then logically the base of the "Lower Sundance" should be drawn at that position. Thus redefined the "Lower Sundance" of both east and west Wyoming would consist exclusively of beds of Callovian age and should be named and given formational rank equivalent to that of the Rierdon formation of Montana (Cobban, 1945).

Since the foregoing suggestions were made (Pipiringos, 1953, p. 35, 37), it has been proposed independently by Peterson that the names Swift and Rierdon be applied to the "Upper Sundance" and "Lower Sundance" of the Powder River Basin and adjacent areas, and that the Sundance formation be raised to the rank of a group (Peterson, 1954, p. 465, 469, 473).

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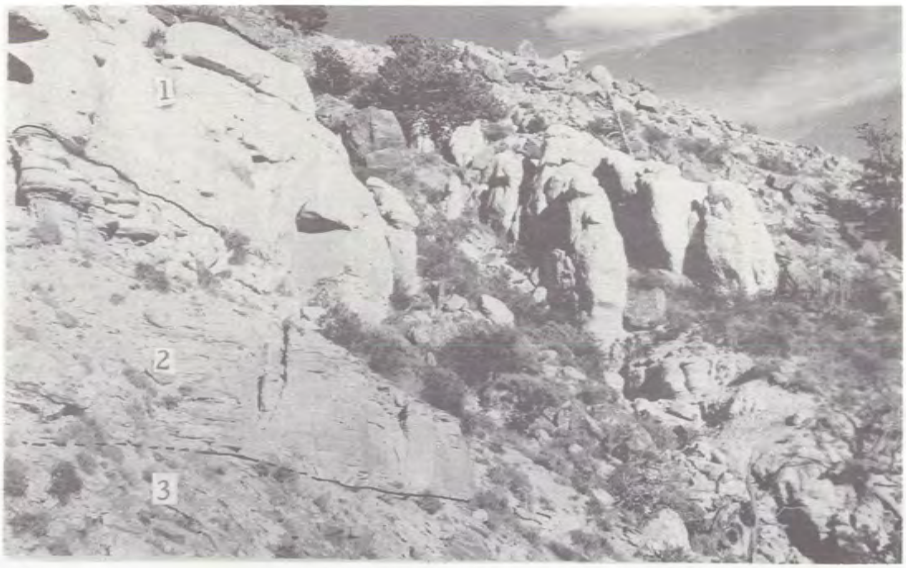
PLATE 1

A. Northeast Freezeout Hills. Eastward view of member A (1), Redwater shale (2), member B (3), Lak (4), Hulett sandstone (5), Stockade Beaver shale (6), and Canyon Springs (7) members of the Sundance formation; Nugget sandstone (8); and the upper member of the Jelm formation (9)

B. East Flat Top anticline. Southward view of the upper member (1) and the lower member (2) of the Jelm formation, and the Chugwater formation (3)

PLATE 2



A. East Freezeout Hills. Southeastward view of a lenticular sandstone bed at the base of the Morrison formation (1); the type section of member A (2), and the Redwater shale member (3) of the Sundance formation

B. East Freezeout Hills. Southward view of the Canyon Springs sandstone member of the Sundance formation (1); the Nugget sandstone (2); and the upper member (3) and the lower member (4) of the Jelm formation

PLATE 3

A. Como Bluff. Eastward view of member A (1), Redwater shale member (2), member B (3), Lak member (4), and Canyon Springs sandstone member (5) of the Sundance formation; and the Nugget sandstone (6)

B. Centennial. Eastward view of member A (1) and the Redwater shale member (2) of the Sundance formation

PLATE 4

A. Red Mountain. Northeastward view of the lower member of the Jelm formation (1) and the Chugwater formation (2)

B. Bull Mountain, Colorado. Close-up showing channel at contact of Jelm formation (1) with the Chugwater formation (2)

STRATIGRAPHIC SECTIONS

In the following stratigraphic sections, the beds are numbered consecutively from oldest to youngest. The first part of each description treats with lithologic features such as grain size, nature of the matrix, etc., as determined from the examination of lithologic samples by means of the binocular microscope. The second part deals with features observed in the outcrop, such as bedding, fracture, topographic expression, etc. The last part of each description concerns the faunal content (if any), in which fossils are listed in the order of abundance; the most numerous first and the least numerous last. The abbreviation "FC" means fossil collections. The word fragment is used to denote a fragment of the original shell material.

By coquinal limestone is meant a rock type intermediate between a coquina and a highly fossiliferous limestone. The adjective "blocky", when used in connection with claystone refers to the peculiar manner in which that rock fractures. A typical formation exhibiting this type of fracture is the Morrison. The claystone of this formation breaks into rectangular fragments whose surfaces are roughly convex-concave. Sometimes the term joint-shale (oral communication, S. H. Knight) has been used to denote the same feature.

Compass directions for offsets are to be reversed when the section is examined from bottom to top. The thickness of a unit is totaled at the end of the description of that unit.

The description of the lithology is entered into with more than usual detail in the hope that it may be of value in recognizing some of these beds in subsurface samples.

SECTION I: NORTHEAST FREEZEOUT HILLS

The Northeast Freezeout Hills section was measured in the NW 1/4 and the SE 1/4 SE 1/4 Sec. 33, T. 26 N., R. 79 W., and portions of adjoining sections to the south and southwest. The area lies about 20 miles north of Medicine Bow, Wyoming, on the Richards Brothers Ranch. The Dyer Ranch referred to by earlier workers in this region is the present (1948) Richards Brothers Ranch.

The strata in this area strike north and dip east. The dip ranges from 9 degrees in the Alcova limestone to 4 degrees in the Sundance formation. A short distance north of the measured section, the strike of the beds swings sharply to the west.

The measurements were made across a valley bounded on the west by the Alcova hogback and on the east by the steep slopes below the high Cloverly ridge. The slope below the Cloverly formation is interrupted by ledges made by member A of the Sundance, by the basal bed of member B, and by three minor ledges made by the Hulett sandstone. The Canyon Springs sandstone member of the Sundance and the Nugget sandstone make a vertical cliff some 50 feet high. Most of the valley is cut almost entirely on the Jelm formation (Pl. 1, A).

Bed	Feet	Description
Morrison formation (in part)		
57	10.0	Interbedded limestone, sandstone and claystone, green-gray.
Contact of the Morrison with member A of the Sundance formation		
56	8.0	Sandstone, gray-white, weathers gray-brown to yellow-tan, very fine to medium-grained, lime-cemented, glauconitic(?). Cleavage faces on calcite crystals in the matrix give a sheen to fresh fractures. Clear subrounded quartz grains imbedded in the lighter colored matrix give a "tapoica" appearance to weathered surfaces. Forms a prominent ledge; the top 1 foot is soft, silty, and makes a reentrant.
55	4.0	Claystone, black, limy, with a thin siltstone parting.
54	3.5	Limestone, yellow-tan, weathers gray-green, very finely crystalline, siliceous, sandy, clayey, hard, conchoidal fracture, with sporadic white banded agate nodules. The limestone has a 6-inch yellow-tan sandstone parting that is similar to Bed 56 above, and is the lithologic continuation of bed 9 of supplementary section IA. Very thin green shale partings are also present. The bed forms a small double-ledge. From the limestone: FC 112, Pholadomya sp., Pleuromya sp., Tancredia(?) 2 spp., Camptonectes bellistriatus; all casts but the last, which is a fragment.
	15.5	Total thickness of member A
Contact of member A with the Redwater shale member of the Sundance		
53	0.4	Limestone, gray-white, finely crystalline, siliceous, clayey, sandy, glauconitic. Forms a ledge. FC 111, Camptonectes bellistriatus, Pleuromya subcompressa(?), worm(?) burrow. All are casts.
52	0.8	Siltstone, green-black, very clayey, limy, blocky fracture.
51	0.8	Limestone, identical to Bed 53. FC 110, Camptonectes bellistriatus cast, Volsella(?) cast.
50	3.3	Claystone, black, noncalcareous, blocky.
49	5.2	Siltstone, green, fine-grained, limy, cross-bedded, intercalated with hard ledge-forming greenish sandstone. The uppermost sandstone ledge is highly glauconitic.
48	80.0	Shale, arbitrarily divided into intervals for the purpose of description: Shale 9', black, limy, fissile, with a 3-inch sandy clayey limestone at the top. Shale 6', same, with many thin beds of sandy limestone which contain fossil fragments. Shale 8', black, limy, silty, fissile, with numerous hard limy silty sandstone layers 2 to 6 inches thick. The top of this interval is an 8-inch bed of gray-green glauconitic coquinal limestone. FC 109, Meleagrinella curta shells partly replaced by pyrite-limonite, Ostrea sp. fragments, Tancredia corbuliformis cast, Oxytoma wyomingensis fragments partly replaced by pyrite-limonite. Shale 12', black, limy, at the top is a 4-inch siliceous sandy limestone bed that contains smooth gray limestone concretions. In the middle is a 6-inch gray-purple limestone layer. The lower 2 feet contains smooth gray limestone concretions. Both concretionary zones contain Pachytheuthis "densus" fragments.

Bed	Feet	Description
		Shale 6', black, limy, with thin green siltstone partings.
		Shale 6', black, limy, with thin lenticular limestone layers in the middle that contain Pachyteuthis "densus", Meleagrinella(?) sp., and Camptonectes(?) sp. fragments. The lower 2 feet of this interval contains smooth gray sublithographic septarian limestone concretions. The septa of the concretions are made of pink coarsely crystalline calcite.
		Claystone and shale 12', green-black, blocky, papery, with very fine grained silty sandstone partings, limonitic streaks are associated with the partings; the shale is least limy. A 4-inch siltstone layer in the middle contains a few nacreous shell fragments partly replaced by pyrite-limonite. Selenite crystals are common in the lower 6 feet.
		Claystone 6', green-black, blocky to shaly, with thin clayey siltstone partings.
		Siltstone and claystone 6'. The siltstone is dark gray-green, very limy, very fine grained with abundant yellow-green glauconite grains, and contains Pachyteuthis "densus" throughout. Limonitic siltstone concretions are common near the top.
		Claystone 6', gray-black, blocky to shaly, selenite crystals are common throughout. At the base is a 1-foot bed of green-gray fine-grained sandstone. The greenish cast is caused by the presence of abundant glauconite grains.
		Shale 6', dark-green, silty, limy, glauconitic, contains selenite crystals. Near the top are some irregular nodules of gray finely crystalline laminated limestone. Ooliths and glauconite grains are present but not common. From the nodules: FC 108A, Camptonectes bellistriatus(?) fragment and Cardioceras(?) sp. casts. In addition, a fragment of Cardioceras sp. cast was found lying loose on the surface of this interval 2 feet above the base.
	84.0	Total thickness of the Redwater shale
Contact of the Redwater shale with member B of the Sundance		
47	5.0	Sandstone and siltstone interbedded in layers 1/4 to 1/2 inch thick, with thin green claystone partings. The sandstone is green-white, very fine to fine grained, limy, with numerous green clay inclusions. The siltstone is gray-white, calcite-cemented, glauconitic, contains many red, orange, yellow and black grains. The siltstone is slabby, and contains thin films of brown-red micaceous clay on the bedding surfaces that resemble flattened pelecypod casts. The claystone is light green-gray, very silty, lime-cemented, glauconitic, and has thin shale partings in places. The overall color of the bed is green-gray. The interval forms a slope.
46	4.0	Sandstone, red-brown above, green-white below, limy, clayey, forms a sandy slope.
45	4.0	Sandstone, white, weathers light brown, very fine grained, lime-cemented, clayey, with a few green glauconite grains present. Green-white ooliths with green clayey glauconite nuclei are common. In addition orange and red grains are numerous. The sandstone is slabby, ripple-marked above, and cross-bedded below. Forms an overhanging ledge.
	13.0	Total thickness of member B
Contact of member B with the Lak member of the Sundance		
44	32.0	Redbeds: Sandstone, orange-red, very fine to fine-grained, limy. The basal 5 to 7 feet of this unit is "bleached" green-white. The sandstone is massive, soft, and forms a sandy slope interrupted by a ledge of white sandstone 1 foot thick, 12 feet below the top of the member.
	32.0	Total thickness of the Lak member
Contact of the Lak member with the Hulett sandstone		
43	8.0	Sandstone, green-white to cream, fine-grained, well sorted, limy, slightly silty, friable, massive, with one green shale parting 2 feet from the top; two zones of siltier sandstone, 3 to 6 inches thick, form reentrants on the ledge face.
42	1.5	Shale, green, papery-fissile, noncalcareous.
41	3.5	Sandstone, green-yellow to green-white, massive, lithology identical to Bed 43. Forms a ledge; the upper 1 foot is softer and makes a slight reentrant.
	13.0	Total thickness of the Hulett sandstone
Contact of the Hulett sandstone with the Stockade Beaver shale		
40	16.3	Interbedded shale, limestone and sandstone, in beds 1/2 foot to 1 1/2 feet thick. The lithology of this member is the same throughout, and is described in detail in the underlying beds. Bed 41 rests disconformably on a green fissile shale at the top of this interval. Fossiliferous throughout; top 1 foot: FC 106, Camptonectes extenuatus(?) cast, worm(?) burrow cast, Pleuromya(?) sp. cast, Tancredia sp. cast; 8 feet below top: FC 105, Meleagrinella orbiculata cast, very numerous; Tancredia corbuliformis(?) cast, Pleuromya sp. cast.
39	2.7	Shale, green, papery, limy, interbedded with gray sandy cross-laminated siltstone that forms thin small ledges.
38	1.0	Sandstone, green-gray, hard, platy, cross-laminated; blocky vertical fractures; ledge-former; contains fossil fragments.
37	2.0	Siltstone, green, sandy, limy, massive to poorly bedded, forms reentrant.
36	1.0	Sandstone, green-gray, very limy, ledge-former.
35	1.5	Siltstone, green to yellow-gray, sandy, massive to poorly bedded.

Bed	Feet	Description
34	1.0	Limestone, gray, weathers cream-buff, very sandy, very finely crystalline, glauconitic, cross-laminated to thin-bedded, brown calcareous ooliths and large well-rounded, frosted red, pink, and yellow quartz grains are abundant along cross-bedding planes. FC 104, Camptonectes extenuatus(?), Tancredia corbuliformis(?), Trigonia(?) sp., casts. In addition, one specimen of Amphiura n. sp., a brittle star, was collected (Fig. 2). The brittle star was found lying loose on the surface 2 feet above the base of the Stockade Beaver shale on an outcrop some 1,700 feet south along strike from where Bed 34 was measured. The lithology of the specimen collected, and the Meleagrinella orbiculata casts with which it is associated, leaves no doubt but that it came from the upper portion of this member.
33	10.0	Sandstone, gray-white, calcite-cemented, moderately hard, massive to obscurely bedded, weathers into vertical, rough, knobby face. A thin hard zone 3 feet from the top, makes a small ledge containing FC 103: Tancredia(?) sp. cast, Trigonia(?) sp. cast, Pleuromya subcompressa(?) cast, Camptonectes sp. fragments, worm(?) burrow cast.
	35.5	Total thickness of the Stockade Beaver shale
Contact of the Stockade Beaver shale with the Canyon Springs sandstone member of the Sundance		
32a	10.0	Sandstone, yellow-white weathers yellow-buff, very fine grained, limy. Lithologically similar to the underlying Nugget sandstone; differs from it only in that the Canyon Springs sandstone contains more limonitic material, which is generally layered rather than nodular, and in being plane-bedded rather than cross-bedded.
	10.0	Total thickness of the Canyon Springs sandstone
	213.0	Total thickness of the Sundance
Contact of Sundance formation with the Nugget sandstone		
32	40.0	Sandstone, yellow-white, weathers yellow-buff on steep or vertical surfaces and buff to gray on horizontal or gently sloping surfaces; very fine grained, limy. Medium-to coarse-grained well rounded, pitted and frosted quartz and chert grains are numerous throughout. The grains are clear, white, red, orange, brown, and gray in color, and are abundantly concentrated along laminae traces and surfaces. The lightest colored grains are the most rounded. Hard brown limonitic nodules project from the cliff face throughout. The sandstone is highly porous, soft, friable, massive, cross-bedded on a large scale, and forms a conspicuous cliff which weathers into rounded forms and spalls off in sheets curved parallel to the cliff face.
	40.0	Total thickness of the Nugget sandstone
Contact of the Nugget sandstone with the upper member of the Jelm formation		
31	28.0	Sandstone, yellow-buff to pink, poorly exposed. The lithology is similar to Bed 32, with perhaps fewer large rounded grains present. Outcrops of several ledges throughout this interval suggest that this sandstone is bedded.
Offset south about 1,760 feet to the top of the east bank of the main stream bed where the upper member of the Jelm formation is exposed in two small isolated ledges.		
30	22.0	Sandstone, green-gray, weathers brown-gray, grades from fine-grained above to medium-grained below, lime-cemented, cross-laminated, moderately hard, makes slabby ledge. At the base is a conglomeratic zone that contains pebbles and cobbles up to 4 inches in length, composed of hard siltstone, sandstone and sandy limestone. The entire bed contains an abundance of dark mineral grains, flakes, and large rounded quartz and chert grains.
	50.0	Total thickness of the upper member of the Jelm
Contact of the upper member with the lower member of the Jelm		
29	6.0	Shale, red-brown, weathers purple-red, noncalcareous, papery-fissile.
28	13.4	Sandstone, gray to mottled green-gray and red-brown, fine-grained, lime-cemented, dark mineral grains and flakes are common, cross-laminated, forms a slabby ledge.
27	21.5	Claystone and siltstone, red-brown, slightly limy, with some greenish zones. In the center is a gray-green very fine grained lime-cemented sandstone that weathers brown, is hard, cross-laminated, and makes an 8-inch ledge.
26	1.5	Sandstone, white, fine-grained, lime-cemented, hard.
25	1.5	Siltstone, green, limy, one thin red-maroon shale parting in middle.
24	1.0	Sandstone, green-white, very fine grained, lime-cemented, silty, hard.
23	8.5	Sandstone, gray, very fine grained, glauconitic(?), with small green clay inclusions, thin-bedded, with mica flakes conspicuous on bedding surfaces. Makes a weak ledge.
22	8.5	Sandstone, cream-white, weathers gray-white, very fine to fine-grained, noncalcareous, glauconite common but difficult to distinguish, massive, finely laminated, highly porous. Many of the sand grains have developed perfect quartz crystal terminations. Scattered throughout are many well rounded, frosted quartz grains as in units above. Forms a ledge. The base of the bed is covered.
Offset northwest 1,000 feet to the top of a knoll a few feet east of the steel post marking a fence corner. This fence is on the township line, and 500 feet west of the fence corner is a steel pipe and brass cap marking the southwest corner of section 33, T. 26 N., R. 79 W.		
21	5.0	Covered.
20	0.5	Sandstone, white, very fine grained, silty, limy, makes weak ledge.
19	2.5	Shale, red and green, noncalcareous, fissile.

Bed	Feet	Description
18	2.0	Sandstone, white, very fine grained, calcite-cemented, sparkly. Orange, red, yellow and black grains are present. Streaks and aggregates of dark mica flakes are common. Contains one thin red shale parting near the top.
17	1.0	Shale, brick-red, with a thin green zone at the top, noncalcareous. Sparkling clear mica flakes line the bedding surfaces.
16	0.5	Siltstone, bright green, limy, clayey.
15	1.0	Sandstone, green-white with scattered blotches of red coloration, fine-grained, limy, silty. A few red-brown, red, orange, yellow and black grains are present. The bed is moderately hard and grades into the subjacent unit.
14	4.0	Shale, yellow-green, limy, silty, with a few orange and yellow sand grains. Contains some siltstone inclusions.
13	3.0	Sandstone, yellow-white, limy, fine-grained with a few coarse, clear, gray, very well rounded quartz grains; moderately hard, massive to irregularly bedded, forms a rounded ledge. The base is covered.
12	5.0	Covered. The contact of the Jelm formation with the Alcova limestone is concealed.
	87.0	Total thickness of the lower member of the Jelm
	137.0	Total thickness of the Jelm
Contact of the Jelm formation with the Alcova limestone member of the Chugwater formation		
11	4.0	Limestone, gray-black, laminated; intercalated with and grading down into gray and pink, silty, fine- to coarsely-crystalline limestone. The entire unit is thin bedded, fossiliferous and glauconitic. The glauconite is in silt-size grains, and rare. Ooliths are common; some are multi-chambered, globose, planispiral and bear a startling resemblance to foraminiferal tests. This bed forms the crest of the Alcova ridge, and the Alcova dip slope. FC 102, Pleurophorus(?) bregeri fragments.
10	2.0	Limestone, purple to green-brown, crystalline, sandy; laminated, ripple-marked, in beds 1 to 4 inches thick. FC 102.
9	1.5	Limestone, green-gray, slabby, in irregular beds 1/4 inch to 3 inches thick. FC 102.
8	1.5	Limestone, gray, weathers green on bedding surfaces, in beds 1/4 inch to 14 inches thick. Small folds up to 7 inches wide and 3 inches high give a crinkly appearance to the rock.
7	1.0	Limestone, gray, blocky, has vertical fracture and is unevenly thin-bedded.
6	1.0	Limestone, green-gray and gray-white, sandy, fine-grained, has conchoidal fracture and is massive. From the basal 6 inches: FC 101, Natica(?) lelia.
	11.0	Total thickness of the Alcova limestone
Contact of the Alcova with the main body of the Chugwater formation		
5	1.0	Limestone, green-white, very silty, with many large well rounded frosted medium grains of quartz. The limestone is reentrant and grades into the underlying bed.
4	3.5	Sandstone, green-yellow, fine-grained, lime-cemented, glauconitic(?). Coarse-textured subrounded to well rounded quartz grains are common. Some fine-grained black mineral aggregates are present. The rock is massive and friable.
3	1.0	Limestone, weathers gray-green, dense, silty. Silt-size glauconite(?) grains are common. Cleavage faces give the rock a sheen. The bed is massive and makes a hard ledge.
2	1.5	Sandstone, green-white, very fine grained, lime-cemented, with many green clay inclusions. The bed is in slabs 1/2 to 1/4 inch thick.
1	400.0+	The rest of the Chugwater exposed here is composed primarily of red-brown shale, siltstone and sandstone.
Base of measured section.		

SECTION I-A: NORTHEAST FREEZEOUT HILLS, SUPPLEMENTARY

The supplementary section was measured near the top of the southeast wall of the second gully 100 yards south of the locality where the upper Sundance of the main section was measured. The approximate location is the NE 1/4 NE 1/4 Sec. 4, T. 25 N., R. 79 W. Here the Morrison-Sundance contact is very well exposed.

At this locality the lower bed of member A is conspicuous bright orange-yellow and immediately attracts the eye as one approaches the section.

Bed	Feet	Description
Morrison formation (in part)		
15	2.5	Limestone, gray, weathers brown-gray, very sandy, and contains a few black mineral grains; cross-laminated, hard. The bed is massive and makes a vertical-faced ledge.
Contact of the Morrison with member A of the Sundance formation		
14	2.0	Siltstone, yellow-white, limy, sandy, obscurely bedded to massive, and grades into the underlying unit.
13	4.5	Sandstone, gray-white, weathers brown-gray, very fine to medium-grained, lime-cemented. The larger grains

Bed	Feet	Description
		are subrounded to well rounded frosted pitted quartz, while a few are of blue-white chalcedony. Dark mineral grains are very few. The matrix has an opaque, chalky appearance and surrounds the clear grains in the manner of a poorly formed oolite, giving the rock a "taptoca" appearance. The sandstone makes a massive vertical-faced ledge rounded at the top.
12	0.5	Siltstone, green-black, very clayey, limy.
11	3.0	Claystone, green-black, limy.
10	1.0	Siltstone, green-black, very clayey, limy.
9	3.0	Sandstone, yellow, weathers orange-yellow, very fine to fine-grained, lime-cemented. Cleavage faces on calcite crystals in the matrix give the rock a sheen. Colored grains are very few, some are black, a few are green (clayey glauconite?), and the rest are red-orange. The rock weathers to a slabby ledge.
	14.0	Total thickness of member A

Contact of member A with the Redwater shale member of the Sundance

8	2.0	Shale, green-black, limy, fissile, with thin partings of gray-white fine-grained hard limestone that weathers light brown.
7	2.0	Limestone, gray-white, weathers yellow-brown, sandy, with black silty claystone partings. Contains what appear to be fossil casts.
6	3.0	Interbedded thin yellow limy blocky siltstone and claystone, with one thin resistant sandstone ledge in the middle.
5	0.6	Siltstone, yellow-tan, limy, clayey.
4	0.5	Claystone, green-black, limy, silty, with a blocky fracture.
3	0.7	Limestone, gray-black, coarsely crystalline, almost a coquina. Contains Camptonectes sp. fragments and Meleagrinella sp. fragments.
2	0.7	Claystone, yellow-brown, limy, silty, with a blocky fracture.
1	0.5	Limestone, gray-black, coarsely crystalline, almost a coquina. Contains Camptonectes sp. fragments and Meleagrinella sp. fragments. Identical to Bed 3.
	10.0	Partial thickness of the Redwater shale

Base of measured section

SECTION II: EAST FREEZEOUT HILLS

The East Freezeout Hills section was measured in the W 1/2 SW 1/4 Sec. 29, T. 25 N., R. 78 W. The area lies approximately 14.5 miles north of Medicine Bow, Wyoming, 2 miles north of the TB cattle ranch, owned by Denver Miller. References by earlier writers to the TB (Trabing Brothers) springs or homestead are to be identified with Denver Miller's TB ranchhouse. The old name and brand were retained even though the ownership has changed hands and the ranch limits considerably extended.

The topographic expression of the various units is practically identical with that of the Northeast Freezeout section. In general, the beds strike north and dip east. The dip ranges from 9 degrees in the Alcova limestone member of the Chugwater formation to 4 degrees at the top of the Sundance formation. The western flank of the north-south trending valley is cut on the Alcova dip slope; the central part is cut on the Jelm formation and in places on part of the Nugget sandstone. To the east a conspicuous vertical cliff 100 feet high is made primarily by the Nugget sandstone (Pl. 2, B). Above the Nugget cliff rises a series of slopes and ledges cut on the Sundance and Morrison formations. The crest of the Morrison slope is everywhere capped by the bold ridge-forming basal Cloverly sandstone.

Noteworthy in this area, though locally present throughout the Freezeout Hills, is a conspicuous white sandstone cliff-maker at the base of the Morrison formation (Pl. 2, A). This thick unit is highly lenticular. At this locality it is estimated that this sandstone decreases in thickness from 60 feet to a vanishing edge in less than 100 yards. Similar sandstones occur at other horizons. In this particular section, the lenticular sandstone rests on member A of the Sundance. To the southeast, about 1/4 mile, on the flank of the same prominence (locally known as Battle Mountain) a similar sandstone was observed to be well above the top of the Sundance formation and completely enclosed by purplish claystone beds of the Morrison formation.

Bed	Feet	Description
Morrison formation (in part)		
38	60.0	Sandstone, gray-white, very fine to fine-grained, lime-cemented, fair porosity, hard, forms a massive cliff. The sandstone is highly lenticular.
Contact of the Morrison with member A of the Sundance formation (Pl. 2, A)		
37	15.0	Sandstone, gray-white, weathers gray, very fine to fine-grained, lime-cemented, glauconitic, clayey, oolitic, in beds 1 inch to 2 inches thick; slabby, ripple-marked. One slab was observed with two sets of shallow ripple marks normal to each other giving a scale-like appearance to the slab. Quartz grains and fossil fragments project from the weathered surfaces. Some ooliths and fossil fragments are partly replaced by silica. Some glauconite grains appear to be altering to green clay. Forms a vertical slabby ledge. FC 215, Ostrea(?) fragments partly replaced by pyrite-limonite; Pachyteuthis fragments water-worn.
36	3.0	Shale, gray-black, limy, slightly silty, fissile.
35	12.0	Sandstone, green-gray, weathers gray to rusty-buff, very fine to medium-grained, calcite-cemented, almost a very sandy limestone. Glauconite grains are common; ooliths are plentiful. The sandstone is thin bedded, contains black limy shale partings, and forms a vertical ledge. FC 214, Ostrea fragments, Pachyteuthis fragments.
	30.0	Total thickness of member A

Bed	Feet	Description
Contact of member A with the Redwater shale member of the Sundance		
34	5.0	Limestone, gray-green, sandy, ripple-marked, interbedded with gray-black fissile shale and green-brown very fine grained soft sandstone. The basal 4 inches of this bed is a green-gray finely crystalline coquinal limestone containing septarian limestone concretions. The entire interval is highly glauconitic, cross-laminated, ripple-marked, and forms a ledge. From the coquina: FC 213, Ostrea strigulecula fragments form the bulk of the coquina, and Pachyteuthis "densus". Some of the Ostrea shells have networks of tubes as though bored by a wormlike organism, (Serpula?).
33	62.5	Shale, green-black, limy, flaky, with numerous sandy limestone and limy sandstone beds up to 6 inches thick. The limestone and sandstone beds invariably are fossiliferous. The entire interval contains Pachyteuthis "densus", and is glauconitic. From a coquina 30 feet above the base of this bed: FC 212, Ostrea sp. fragments, Tancredia transversa casts, Cidaris bellefourchensis spine fragment. From the basal 5 feet: FC 211, Cardioceras(?) sp. fragment lying loose on the surface.
32	15.5	Claystone, gray-black, limy, silty. Pachyteuthis "densus" abundant. The upper 5 feet of this interval is covered.
	83.0	Total thickness of the Redwater shale
Contact of the Redwater shale with member B of the Sundance		
31	10.0	Shale, gray-green, limy, with very limy sandstone nodules. The nodules are green-gray, weather brown, fine grained, cross-laminated and usually are fossiliferous. From the nodules: FC 209, 208, 207, Ostrea strigulecula(?) fragments, segmented worm trail casts, Lingula brevirostris phosphatic fragments, Tancredia corbuliformis(?) casts.
30	18.0	Redbeds. Sandstone, red-brown, very fine to fine-grained, lime-cemented, shaly and silty in places. Five feet above the base of this bed is an 8-inch ledge of slabby sandstone, green-gray, weathers red-brown, very limy and hard. The bedding surfaces throughout are lined with micaceous red-brown clay. Red-brown clay pebbles resembling small pelecypod casts occur throughout.
29	4.0	Sandstone, gray-white to green-white, weathers gray-brown, very fine grained, lime- and silica-cemented. Contains a few large subrounded polished quartz grains, and some glauconite grains and ooliths. The ooliths have nuclei of glauconite surrounding a sand grain or simply a grain of clayey glauconite. The bed is cross-laminated and forms a ledge. The weathered surfaces are studded with silica-replaced Ostrea fragments. FC 206, Ostrea strigulecula(?) fragments, and a gastropod(?) cast. Some of the ooliths as well as the shell fragments are partly replaced by silica.
	32.0	Total thickness of member B
Contact of member B with the Lak member of the Sundance		
28	33.0	Sandstone, pink-red in the upper 11 feet, green-white below, weathers greenish-yellow, very fine grained, limy, very clayey; green and dark-green glauconite grains are rare but present in the lower part. The bed is massive to shaly, friable, forms a soft sandy gentle slope, and contains a 1-foot green-white sandstone ledge 8 feet below the top.
	33.0	Total thickness of Lak member
Contact of the Lak member with the Hulett sandstone member of the Sundance		
27	13.0	Sandstone, white, slightly yellowish, weathers light tan, very fine to fine-grained, limy; glauconite grains are few. The sand grains are subangular to subrounded sugary textured, impurities are varicolored and inconspicuous. The bed is soft, highly porous, friable, ripple-marked, massive, and forms a vertical ledge. FC 205, burrow(?) casts, tapering, annulated, one fragment is 3 1/2 inches long, 2 by 1 1/4 inches at one end, and 3/4 by 1/2 inch at the other. Shallow narrow rounded furrows encircle the cast at 3/4 to 1 inch intervals.
	13.0	Total thickness of Hulett sandstone
Contact of the Hulett sandstone with the Stockade Beaver(?) shale member of the Sundance		
26	2.0	Shale, ochre-green to olive, noncalcareous, with a few scattered very fine clear quartz grains; papery-fissile, forms reentrant. The presence of this easily eroded unit locally has caused the overlying ledge to retreat more rapidly than the underlying massive cliff, forming a natural amphitheater whose bare floor is formed by the top of the Canyon Springs sandstone.
25	3.0	Sandstone, white, weathers yellow-buff, fine-grained, lime-cemented, with a few well rounded frosted clear medium quartz grains. One minute purple tourmaline crystal was observed. The bed forms a short bare slope.
	5.0	Total thickness of the Stockade Beaver(?) shale
Contact of the Stockade Beaver(?) shale with the Canyon Springs sandstone member of the Sundance		
24a	10.0	Sandstone, yellow-white, identical to the underlying Nugget except that limonitic concretions seem larger and more numerous in the Canyon Springs, and the latter is plane-bedded rather than cross-bedded.
	10.0	Total thickness of the Canyon Springs sandstone
	206.0	Total thickness of the Sundance
Contact of the Sundance formation with the Nugget sandstone		
24	90.0	Sandstone, yellow-white, weathers gray on horizontal or sloping surfaces, and yellow-buff to brown on the vertical cliff-face, very fine grained, limy. Large well rounded frosted quartz and chert grains are numerous throughout, and are especially numerous on laminae surfaces. The color of the large grains is clear, translucent gray, opaque white, rose, purple, orange, and black. The grains in the upper part are more rounded than

Bed	Feet	Description
		are those of the lower part. The bed forms a vertical cliff that shows cross-lamination on a large scale. The contact of this and the underlying bed is gradational within a few feet. There is, however, a strong change of topographic expression in that the underlying Jelm is harder and forms a shelving ledge whose face is about 60 feet updip from the base of the vertical Nugget cliff (Pl. 2, B). An erosional surface was observed in the middle of the Nugget, above and below which no lithologic difference could be perceived.
	90.0	Total thickness of Nugget sandstone
Contact of the Nugget sandstone with the upper member of the Jelm formation		
23	24.0	Sandstone, green-white, weathers gray-white to yellow-green, very fine to coarse-grained, lime-cemented, hard. Dark mineral grains, flakes, and clay pebbles are present throughout, but are larger and more numerous in the basal portion. Angular to well rounded quartz and chert grains are numerous. The rounder grains are frosted. The angular grains are most numerous near the base. The sandstone is cross-bedded, but the cross-beds are shorter and more steeply inclined than those of the overlying Nugget sandstone; weathers into a slabby shelving ledge forming a toe to the Nugget sandstone cliff. See Pl. 2, B.
22	1.0	Conglomerate, green-gray to yellow-brown. The matrix is a mixture of limy green clay, yellow-green siltstone, sandstone, large rounded quartz and chert grains, dark mineral grains, and mica and chlorite flakes. The larger fragments are pebbles, cobbles and boulders, composed of siltstone, sandstone, limestone, bone, and wood fragments. The largest observed were 1 foot in length. All the larger fragments are subangular to subrounded. Pebbles, cobbles and boulders of this conglomerate are imbedded in and firmly cemented to the underside of the overlying bed.
21	5.0	Sandstone, green-gray, to green-white, medium-grained, lime-cemented, hard; dark mineral grains, flakes, and green clay inclusions are common. The sandstone is cross-bedded and forms a vertical-faced ledge. In places the overlying conglomerate channels into this bed.
	30.0	Total thickness of the upper member of the Jelm
Contact of the upper member with the lower member of the Jelm		
20	8.5	Shale, red-brown to red-purple, limy, silty, with shiny mica flakes lining the bedding surfaces.
19	7.0	Sandstone, mottled brown, lavender and green-white, fine- to medium-grained, limy, silty; has pepper-flecked appearance because of numerous dark mineral grains; in layers 1/4 inch to 2 inches thick.
18	1.5	Sandstone, yellow, very fine to fine-grained, interbedded with pink-white fine-grained limy sandstone. Numerous large subrounded to well rounded quartz and chert grains, predominantly white-opaque, gray-pink and black in color, are scattered throughout. Forms a small reentrant.
17	1.5	Sandstone, yellow-gray, very fine to fine-grained, limy, with abundant large subrounded to well rounded quartz and chert grains aligned on cross-bed traces and surfaces. Forms a small rounded ledge.
16	1.0	Sandstone, yellow, weathers red-brown, limy, very silty, with some limonitic streaks; massive, soft, forms a reentrant.
15	2.0	Sandstone, gray, medium-grained, massive; many of the grains are colored pink, black, yellow, orange, and white. Forms a ledge.
14	16.5	Sandstone, mottled red and green, very fine grained, limy, silty, thin-bedded, contains a nonmottled 4-inch zone 7 feet above the base. Forms a ledge.
13	5.0	Claystone, red-brown, limy, with a few thin layers of green very fine grained limy sandstone.
12	5.0	Sandstone, gray-red, fine-grained, very limy, interbedded with thin layers of red noncalcareous shale and siltstone. The sandstone is hard, has a blocky vertical fracture, and is ripple-marked. The ripple-marks are closely imbricated giving a striated appearance to fractured or weathered surfaces. Forms resistant ledges. The presence of this type of hard limestone-like, ripple-marked, striated, ledge-forming sandstone seems quite characteristic of the redbed lithology of the lower member of the Jelm formation in all sections examined.
11	11.0	Sandstone, mottled red and green, fine- to medium-grained, limy; orange-pink and dark mineral grains are common. The lower half is massive, the upper half is thin-bedded. Coarse-textured subrounded to well rounded frosted sporadic grains are common throughout, but in the bedded upper half the grains appear to be more numerous in the layers which form reentrants. In addition, the layers which form reentrants are also the least limy.
10	5.0	Sandstone, gray-green, fine- to medium-grained, limy, with some orange-pink and dark grains present; in beds 1 inch to 8 inches thick. The bedding planes are ripple-marked. At the top is a 6-inch zone of red silty fine-grained very thinly bedded sandstone that grades up into a 2-inch red-brown shale bed. The upper half of the sandstone forms a reentrant.
9	11.0	Sandstone, green-white, weathers gray-yellow, medium-grained, limy; moderately soft, forms a rounded ledge. The lower part is harder and projects beyond the upper. In addition it is cross-laminated, and contains many subrounded to well rounded frosted coarse quartz grains.
8	13.0	Sandstone, green-gray, medium- to coarse-grained, limy, with many pink and black grains, massive. The basal foot has many large well rounded pitted polished gray quartz grains. Forms a rounded shoulder.
7	3.0	Claystone, green in the lower part, red in the upper, noncalcareous.
6	1.0	Sandstone, green, weathers green-brown, fine-grained, very limy, almost a limestone; in layers 1 inch to 2 inches thick. Forms a small resistant ledge.
5	8.0	Sandstone, green-yellow, weathers tan, very fine grained, limy, clayey, soft, massive. The topmost 1 foot is slabby, with green micaceous films of clay on the bedding surfaces. The contact with the underlying unit is covered.
4	10.0	Sandstone, yellow, weathers tan, very fine grained, very limy; contains a few very fine dark mineral grains and

Bed	Feet	Description
		dendritic growths. The sandstone is thin-bedded in the lower half and thick-bedded in the upper. The top 4 feet is covered. The whole forms a partly covered slope. The lithologic change from this to the underlying unit is rapidly gradational.
	108.0	Total thickness of the lower member of the Jelm
	138.0	Total thickness of the Jelm

Contact of the Jelm formation with the Alcova limestone member of the Chugwater formation

3	12.0	Limestone, pink-white to white above, pink-gray to gray below, finely crystalline, sandy at the top, hard. Small folds are present in the bottom 3 feet that vary from 6 inches to 1 1/2 feet in length and 2 to 6 inches in height. This interval forms the upper part of the Alcova hogback and dip slope. It is fossiliferous throughout: FC 203 from top, Pleurophorus(?) bregeri and FC 202 from the base, Pleurophorus(?) bregeri and Natica(?) lelia. The top 1 foot contains lobed ooliths resembling foraminifers.
2	2.5	Limestone, gray-pink, sandy in lower 6 inches, dense, hard, conchoidal fracture, has a few pyrite-limonite streaks; in beds 3 inches to 1 foot thick, cross-laminated near the top, bedding planes are ripple-marked. This limestone forms the lower part of the ledge-face of the hogback. FC 201, Pleurophorus(?) bregeri and Natica(?) lelia.
	14.5	Total thickness of the Alcova

Contact of the Alcova with the main body of the Chugwater formation

1	8.0	Sandstone, white, weathers green-gray, very fine to medium-grained, lime-cemented, glauconitic(?), with numerous coarse subrounded to well rounded, polished quartz and chert grains. The sandstone is massive to thin-bedded, moderately soft, and forms a reentrant. The base of this interval is covered. There is at least 200 feet of typical Chugwater redbeds exposed below this bed.
	3.0	Partial thickness of main body of Chugwater

Base of measured section

SECTION II-A: EAST FREEZEOUT HILLS, SUPPLEMENTARY

The supplementary East Freezeout Hills section was measured on the south flank of the same prominence as the main section. It is located near the base of the north slope of the first wind gap north of the TB ranch. The approximate location is the SE 1/4 SE 1/4 SW 1/4 Sec. 29, T. 25 N., R. 78 W.

Bed	Feet	Description
		Redwater shale member of the Sundance formation
10	80.0+	Shale, green-black, limy, forms a covered slope whose surface is littered with Pachyteuthis "densus".
		Contact of the Redwater shale with member B of the Sundance
9	5.0	Sandstone and limestone intergrading, green-gray, weathers gray-brown, glauconitic, oolitic; ripple-marked, cross-laminated, hard, forms a vertical-faced blocky ledge. Fossil fragments are numerous. The bed is a near-coquina. FC 207A2 and FC 207A1, Ostrea strigulecula fragments, Lingula brevirostris phosphatic fragments, Trigonia sturgisensis, Camptonectes sp., Pentacrinus(?) sp., sandy casts.
8	5.0	Shale, green-gray, weathers blue-gray, limy, silty, fissile, with numerous small rounded or irregular-shaped, sandstone nodules that are very fine grained, lime-cemented, hard, sparsely glauconitic, and laminated. The surfaces of the nodules usually have fossil impressions or burrow casts. The bed forms a slope.
7	18.0	Claystone, red-brown to red-purple, very silty, limy, blocky to flaky.
6	3.0	Sandstone, gray-white, weathers greenish-gray to gray-brown, very fine grained, calcite-cemented, glauconitic. Ooliths with green clayey glauconite nuclei are common. The bed is hard, ripple-marked, cross-laminated, and forms a vertical-faced ledge. The weathered surfaces are studded with silica-replaced Ostrea fragments. The moderately irregular surface separating this from the underlying bed seems to be one of erosion.
	29.0	Total thickness of member B

Contact of member B with the Lak member of the Sundance

5	1.7	Sandstone, mottled pink-red and gray-green, very fine grained, micaceous, irregularly thin-bedded, soft, forms a reentrant.
4	3.3	Claystone, red-brown, silty, slightly limy, micaceous, flaky, soft, forms a partly covered slope.
3	2.6	Sandstone, white, slightly tannish, weathers gray-white, very fine grained, limy, sparsely glauconitic; friable, thick-bedded, laminated, forms a small projecting ledge. The lithology is similar to that of the Hulett sandstone.
2	2.7	Sandstone, green-yellow, very fine grained, very limy, very clayey; soft, friable, shaly, forms a sandy slope. The uppermost 3 feet is red-maroon.
	34.6	Total thickness of the Lak member

Contact of the Lak member with the Hulett sandstone member of the Sundance

1	11.0+	Sandstone, white, slightly yellowish, weathers light tan, very fine to fine-grained, limy, sparsely glauconitic, friable, ripple-marked, forms a vertical ledge. The base of the ledge is concealed by talus.

Base of the measured section

SECTION III: EAST FLAT TOP ANTICLINE

The East Flat Top anticline section is located in the SE 1/4 NE 1/4 Sec. 22, and in the SW 1/4 NW 1/4 Sec. 23, T. 23 N., R. 78 W. The section was measured on the south flank of Flat Top anticline some 5 miles north of Medicine Bow, beginning about 4,000 feet northeast of the steel bridge on the Little Medicine Bow River. The strata strike north and dip east; the dip ranges from 27 degrees in the Chugwater to 9 degrees at the top of the Sundance formation. Measurements and descriptions were made along the banks of a spring-fed stream that traverses the area from east to west in practically a straight line. The trend of the south flank of Flat Top anticline is east-west in general, but in the locality under consideration the strike swings sharply northward for about a mile and then resumes its former direction.

As in the previous sections, that part of the Jelm formation directly above the conglomerate is resistant to weathering and erosion. Because of the higher dips, the upper member of the Jelm forms a ridge instead of a shelving ledge (Pl. 1, B).

In general, that part of the succession below and including the Jelm forms a series of bold, perfectly exposed ledges, hogbacks and dip slopes. Above the Jelm, the Nugget sandstone and Sundance formation form a valley and gentle slopes which are mostly covered. Member A of the Sundance formation forms a fairly prominent ledge.

Bed	Feet	Description
Morrison formation (in part)		
57	10.0	Interbedded limestone, shale and sandstone, green to gray.
Contact of the Morrison with member A of the Sundance formation		
56	1.0	Sandstone, white, weathers gray, lime-cemented, contains orange and red quartz and chert grains, and a few black mineral grains. The texture is that of tapoica. The bed is hard, irregularly bedded and makes a blocky ledge with vertical fractures.
55	5.0	Claystone, green to lavender to pink, limy, sandy.
54	2.0	Claystone, green-gray, weathers green-black, limy, sandy, impure. The upper 1 foot of the bed contains pink-gray smooth dense hard septarian limestone concretions up to 4 inches in diameter, whose septa are composed of clear calcite crystals.
53	4.0	Sandstone, yellow-white, weathers yellow-buff to brown, fine-grained, calcite-cemented, contains a few large rounded polished quartz grains and a few dark mineral grains. Wet weathered surfaces have a distinct "tapioca" appearance. Yellow clay streaks are present on some of the bedding planes. The sandstone is thin-bedded, slabby, ripple-marked, and makes a hard blocky ledge.
	12.0	Total thickness of member A
Contact of member A with the Redwater shale member of the Sundance		
52	71.0	Shale, black to gray-black, limy, silty, sandy, glauconitic, contains thin sandstone and sandy limestone beds that are more numerous near the top. Selenite crystals are abundant in the lower part of the bed. The shale forms a gentle partly covered slope. Pachyteuthis "densus" is common throughout. From a lenticular glauconitic sandstone 3.5 feet below the top: FC 306, Ostrea strigulecula fragments partly replaced by pyrite-limonite, Meleagrinella curta(?) fragments, fish(?) scales and vertebra(?) fragments. From a zone of pink-brown oolitic coquinal limestone concretions 30.0 feet below the top: FC 305, Meleagrinella curta fragments and impressions. The average length is 1/4 inch. The largest found is 1/2 inch. From a green fine-grained calcite-cemented glauconitic sandstone 45.0 feet below the top: FC 304, Meleagrinella curta shells abundant, up to 1/4 inch in size, Oxytoma wyomingensis shells, Ostrea sp. fragments. In each group some of the shells and fragments are partly replaced by pyrite-limonite.
	71.0	Total thickness of the Redwater shale
Contact of the Redwater shale with member B of the Sundance		
51	2.0	Sandstone, green-white, weathers green-gray, very fine grained, lime-cemented, glauconitic; slabby, cross-laminated, forms a ledge. Contains a few Ostrea sp. fragments.
50	3.0	Siltstone, gray-green, limy, clayey, sparsely glauconitic, contains thin cross-laminated sandstone lenses.
49	4.0	Sandstone, green-white, weathers gray, very fine to fine-grained, lime-cemented, silty, highly glauconitic, with green shale partings. Contains pseudomorphs of limonite after pyrite up to 1/4 inch in size, and some irregularly rounded pyrite-limonite concretions; some brown-black organic material is present also. The sandstone is thin-bedded, slabby, ripple-marked, cross-laminated in part and makes a low ridge. FC 303, Ostrea strigulecula fragments partly replaced by silica, worm(?) burrow casts, Camptonectes extenuatus(?) casts, Tancredia(?) sp. casts, gastropod(?) cast. Fossils are abundant but poorly preserved; many of the fragments are partly replaced by pyrite-limonite.
48	1.5	Shale, yellow-green, limy, fissile.
47	2.5	Sandstone, white, fine-grained, lime-cemented, glauconitic, soft, contains fossil fragments.
46	5.0	Shale, dark-green, very limy, very silty, fissile to blocky.
45	3.0	Sandstone, gray-white, weathers gray-brown, very fine grained; contains abundant glauconite grains and a few pyrite-limonite concretions. The sandstone contains thin green shale partings throughout, has a thin gypsiferous zone at the base, is thick-bedded above, thin-bedded below, ripple-marked, cross-laminated, and makes a small ledge. FC 302, Ostrea strigulecula fragments, Tancredia corbuliformis(?) casts, worm(?) burrow casts, tracks, Trigonia sturgisensis casts, Camptonectes extenuatus(?) casts.
44	3.0	Shale, yellow-green, limy, sandy, with a few dark mineral grains present. Contains cross-laminated lenticular glauconitic thin sandstone layers, pyrite-limonite concretions, and is gypsiferous. From the lenticular sandstone: FC 301, Tancredia transversa(?) casts numerous, Pleuromya(?) sp. casts.
43	3.0	Shale, green, limy, silty, fissile, with a few lenticular sandstone nodules.

Bed	Feet	Description
42	3.0	Shale, blue-gray, weathers bright blue, limy, fissile, uniform.
41	3.0	Redbed. Siltstone, red-brown, lime-cemented, dark-brown clay streaks are common; bedding surfaces are lined with mica flakes.
40	9.7	Shale, green, interbedded with claystone, green-yellow sandy siltstone and sandstone, in beds up to 3 inches thick. All are limy. The sandstone layers make numerous small ledges.
39	1.0	Siltstone, green-white, lime-cemented, glauconitic, with a few dark minerals. Contains a spongy network of selenite crystals, has many thin green shale partings, and makes a small ledge.
38	5.0	Claystone, green-yellow, limy, very sandy; the harder sandier layers make numerous very small ledges.
37	6.0	Sandstone, white, fine-grained, lime-cemented, friable, soft; contains white oolithe with green clayey glauconite nuclei, has "tapioca" appearance. The sandstone is obscurely bedded and forms a slope.
36	2.0	Claystone, green, weathers yellowish, limy, very silty. The upper 4 inches contains selenite crystals.
35	2.3	Sandstone, almost pure-white, fine-grained, lime-cemented sparsely glauconitic, good porosity; has a few large rounded quartz grains. At the base is a limonitic layer that weathers into hard nodules that project from the face of the ledge. The sandstone is cross-bedded and makes a moderately prominent ledge.
	59.0	Total thickness of member B
Contact of member B with the Lak(?) member of the Sundance		
34	31.0	Sandstone, yellow-white, weathers rusty-yellow, very fine to fine-grained, very limy, very friable, soft. Contains a few large grains which are well rounded and polished. This bed makes an almost completely covered slope. The contact with the underlying bed is concealed.
	31.0	Total thickness of the Lak(?) member
	173.0	Total thickness of the Sundance
Contact of the Lak(?) member with the Canyon Springs-Nugget sandstone sequence, undivided		
33	63.4	Sandstone, completely covered. Three samples were collected. The first was secured from the stream bottom (3 feet under water) near the west side of the valley, the second from beneath mud at the base of the vertical bank on the north side of the stream, and the third from beneath the mud at the head of the stream. The first sample is blue-white in color, while the other two are yellow-white. All are very fine to fine grained, limy, porous and friable. The sample from the head of the stream, probably from within a few feet of the top of the Nugget, contains numerous medium to coarse well rounded frosted and pitted quartz grains. The last described sample is probably from the Canyon Springs sandstone member of the Sundance which is estimated to be about 8 feet thick. The contact of the Nugget sandstone with the Jelm formation is covered, but it is probably near the alluvium-Jelm contact along the western margin of the main valley.
	63.4	Total thickness of the Canyon Springs-Nugget sandstone sequence, undivided
Contact of the Nugget sandstone and the upper member of the Jelm formation		
32	28.6	Sandstone, green-gray to green-yellow, weathers green-yellow to gray-brown. The upper part is fine to medium grained, limy, and contains subangular to rounded coarse quartz grains, and some dark mineral grains and flakes. It weathers into massive rounded forms, or into slabs where the cross-bedding is pronounced. The lower part is hard, lime-cemented, medium-to coarse-grained sandstone, and contains large grains of angular to subangular quartz, an abundance of dark mineral grains and flakes, and numerous clay pebbles. The clay pebbles and dark grains are most abundant in the basal part. This bed makes the highest ridge in the area (unit 1 of Pl. 1, B).
31	1.0	Conglomerate, matrix of green-yellow very clayey limy poorly sorted siltstone with scattered abundant medium to coarse rounded polished quartz grains, abundant dark mineral grains and flakes, and numerous clay pebbles. The conglomerate fragments are flattened, subrounded pebbles, cobbles and boulders of hard siltstone, cross-laminated limy sandstone and very sandy limestone, the largest of which is 1 foot in diameter. In addition, small white pieces of fossil bone are present. The overlying bed has fragments of this conglomerate firmly cemented to its under surface. The conglomerate forms a reentrant.
30	0.8	Sandstone, green-gray, medium-grained, lime-cemented, glauconitic(?), hard; has abundant green and black mineral grains and flakes which give a greenish color to the rock. Well rounded polished grains of clear quartz are scarce. This bed forms a projecting ledge. A few yellow clayey siltstone pebbles were found firmly cemented to the underside of this bed. Locally, Bed 30 is cut out and Bed 31 is channeled into Bed 29.
	30.4	Total thickness of the upper member of the Jelm
Contact of the upper member with the lower member of the Jelm		
29	10.0	Sandstone, yellow-white, weathers yellow-buff, fine-grained, silty, lime-cemented, has a few dark mineral grains. The upper 2 to 8 feet is a ledge-maker and seems to channel into the lower part.
28	2.0	Shale, pale-green, slightly limy, soft, fissile; chlorite and muscovite flakes are common, crumbles in part to white powder in acid.
27	4.5	Claystone, red-brown, sandy, limy.
26	3.0	Sandstone, red-brown, very fine grained, very silty, lime-cemented, porous.
25	2.0	Sandstone, green-gray, very fine grained, calcite-cemented.
24	8.0	Claystone, red, sandy, limy.

Bed	Feet	Description
23	0.3	Siltstone, gray-white, lime-cemented, hard, many dark mineral grains; thin-bedded, soft.
22	0.5	Claystone, red-brown, limy, blocky.
21	0.3	Siltstone, similar to Bed 23.
20	0.5	Shale, blue-green, weathers yellow-gray, limy, papery-fissile.
19	0.5	Siltstone similar to Bed 23.
18	0.5	Shale, similar to Bed 20.
17	0.4	Siltstone, completely disbonded on the outcrop. Probably a pink-white gypsum- or lime-cemented siltstone in the subsurface.
16	9.0	Sandstone, pink-white to yellow-white, fine-grained, lime- and calcite-cemented, good porosity, well sorted, friable. The sandstone is cross-bedded and weathers into rounded shoulders.
15	9.0	Sandstone, white, weathers gray-yellow, very fine grained, lime-cemented, contains a few large rounded frosted quartz grains. The sandstone is massive, soft, and weathers into wind-pocked rounded shoulders.
14	8.0	Sandstone, siltstone and shale, interbedded. The sandstone is green, very fine grained, lime-cemented, silty, and contains many dark mineral grains and flakes. The siltstone is yellow-white, lime-cemented, clayey, with numerous green chlorite flakes lining the bedding surfaces. The shale is yellow, limy, platy, and contains numerous selenite crystals. The upper few inches of this bed contains pink chert rosettes up to 1 inch in diameter. The bed weathers yellow-green and forms a partly covered slope.
13	4.0	Sandstone, green-white, very fine grained, lime-cemented, slightly silty, fairly porous, soft, forms a slope.
12	1.5	Sandstone, pink to green-white, weathers yellowish, fine-grained, slightly limy. Large rounded polished quartz grains throughout, especially numerous on the uppermost surface. The sandstone is cross-bedded and makes a slabby ledge. The lithology is strikingly similar to that of the Nugget sandstone.
11	18.5	Sandstone, pink-white, weathers yellow-gray, very fine to fine-grained, lime-cemented sand grains with quartz crystal terminations are common. Forms a massive, wind-pocked ledge. The top 2 feet is softer, and forms a reentrant.
10	8.5	Sandstone, green-white, very fine grained, lime-cemented; large rounded frosted quartz grains are clustered or spread along bedding surfaces. A few green shale partings are present whose surfaces are lined with muscovite, biotite and chlorite flakes. The upper 6 inches consists of interbedded green shale and pink-white, fine-grained noncalcareous sandstone in beds 1/4 to 1/2 inch thick. In these thin beds of sandstone, sand grains with quartz crystal terminations are common.
9	6.0	Siltstone, pink to green-gray, calcite-cemented; abundant dark mineral grains, and a few limonitic nodules are present. The basal part of this bed is blue-gray, hard, cross-laminated, and makes a small projecting ledge that looks like limestone.
8	4.0	Shale, red-brown, very limy, slightly silty, with a few very sandy zones. The top 8 inches is green, papery fissile, and contains a 4-inch zone of gypsum and selenite crystals.
7	1.0	Siltstone, gray-white, calcite-cemented, almost a limestone; forms a hard, slabby ledge and dip slope. Contains current and oscillatory ripple-marks whose surfaces are lined with numerous light and dark mineral flakes.
6	4.0	Claystone, dark-green, limy, sandy, blocky.
5	2.0	Sandstone, white, very fine grained, lime-cemented; forms massive ledge.
4	7.0	Siltstone, mottled green-brown, lime-cemented, sandy; mica and chlorite flakes are numerous. Brown clay pebble inclusions up to 1 inch long, and red-brown claystone partings are present. The siltstone is soft, laminated, and forms a slope.
3	9.5	Sandstone, green-white, weathers gray, very fine grained, lime-cemented, silty, slightly clayey; dark mineral grains and flakes are common. The beds are 2 to 5 feet thick; the upper 5 feet is slabby, soft and makes a reentrant, while the lower part weathers into a rounded wind-pocked ledge that makes the second highest ridge in the area.
	122.3	Total thickness of the lower member of the Jelm
	152.9	Total thickness of the Jelm

Contact of the lower member of the Jelm formation with the Chugwater formation

2	4.0	Interbedded gray-green slabby siltstone with red-brown clayey massive siltstone. Both are lime-cemented, with an abundance of dark and light mineral flakes, and contain a few grains with quartz crystal terminations. Forms a slope.
1	8.0	Siltstone, red-brown, limy, clayey, almost a very fine grained sandstone; weathers into rounded shoulders with a rough ropy surface.

NOTE: In order to avoid overlooking the Alcova limestone or any equivalent that might be present in the East Flat Top section, 358 feet of Chugwater was measured, of which only the upper 12 feet are described (Units 1 and 2). No trace of the Alcova was found. Lithologic features in the undescribed Chugwater which may be of interest are: 1) 179 feet below the base of unit 3; large rounded polished quartz grains in the base of a gray-white sandstone ledge ten feet thick. 2) 266 feet below the base of unit 3; a red-brown and white banded and mottled well sorted gypsum-cemented sandstone bed 1 foot thick. Where the gypsum is leached out yellow-white loose sand remains. The lowest exposure of the Chugwater in this area is a ledge a few feet from the east bank of the Little Medicine Bow River.

358.0 Total exposed thickness of the Chugwater formation

Base of measured section

SECTION IV: WEST FLAT TOP ANTICLINE

The West Flat Top anticline section was measured on the south limb near the west end of Flat Top anticline in the S 1/2 NE 1/4 SE 1/4 Sec. 14 and adjacent parts of Sec. 13, T. 23 N., R. 79 W. The area lies south of the Little Medicine Bow River about 5 1/2 miles northwest of Medicine Bow.

The stratigraphic section was measured from north to south across a westerly trending valley cut on the Nugget sandstone and bounded on the north by the upper Jelm hogback. The south flank of the valley is formed by the slopes of the Sundance which are capped by the ledge formed by member A of the Sundance formation. The strata in this area strike a little north of west and dip southward. The dip ranges from 17 degrees in the lower member of the Jelm to 24 degrees at the top of the Sundance formation.

In the main, the section is well exposed with the exception of the Nugget sandstone and the lower part of the Sundance formation. Here again, because of the relatively high dips, the Nugget sandstone forms a covered valley in contrast to its behavior in the Freeze-out Hills, where with low dips it forms a conspicuous vertical cliff.

Since the topography is similar throughout, no attempt is made to give detailed descriptions of the offsets. Such descriptions would apply to numerous other points along the south slope of the valley cut on the Nugget sandstone.

Bed	Feet	Description
		Contact of the Morrison formation with member A of the Sundance formation
37	5.0(?)	The upper beds of member A were not examined and the thickness given is an estimate.
28	6.0	Sandstone, green-white to gray-white, weathers buff, brown, green-brown and yellow-brown, very fine to medium-grained, calcite-cemented, with cleavage faces giving the rock a sheen. The texture and appearance is that of tapioca. Fine grains of green and dark green glauconite are common. Pink-brown calcite ooliths are abundant at numerous horizons. Upon breaking the ooliths, the internal structure is found to be of two kinds. The first is a layer of white calcite enclosing a quartz grain, while the second is a layer of white calcite surrounding a green grain of clayey glauconite. There are a few dark mineral aggregates present which weather brown-yellow and stain the adjacent matrix. Fossil remains are abundant throughout, but fragmentary and poorly preserved. FC 414, Ostrea sp. fragments numerous, Meleagrinella sp. fragments few, Pentacrinus asteriscus(?) fragment.
	11.0+	Total thickness of member A
		Contact of member A with the Redwater shale member of the Sundance
35	6.3	Shale, gray-black, limy, has sharp-edged subconchoidal fracture. The presence of white calcitic round to almond-shaped fine to medium spherulites gives the shale a spotted, speckled appearance. From a thin gray lime-cemented, glauconitic, cross-laminated sandstone 2 feet below the top of this unit: FC 413, Ostrea sp. fragments, worm(?) burrow casts, Tancredia warrenana(?) and T. corbuliformis(?) casts. From a thin blue-gray highly glauconitic limestone 4 feet below the top of this bed: FC 412, Ostrea strigulecula fragments numerous, Meleagrinella curta(?) fragments, Tancredia warrenana(?) casts, Oxytoma wyomingensis fragments, Camptonectes sp. fragments. The limestone also contains pyrite-limonite cubes up to 1/4 inch in size.
34	0.7	Limestone, gray to pink-brown, coarsely crystalline, glauconitic, coquinal in the lower part with limestone concretions at the base. The coquina is made up of fragments of Ostrea and Meleagrinella so tightly packed and broken it is impossible to make specific identifications.
33	1.0	Sandstone, green-gray, very fine grained, calcite-cemented, glauconitic, and cross-laminated. The lower part is a coquina and contains ovoid limestone concretions at the base. The concretions are as much as 8 inches in diameter. From the coquina: FC 410, Plicatula(?) sp., Meleagrinella curta fragments, foraminifers, Pentacrinus(?) sp. gray-black calcitic flat-sided columnar pentagons, Tancredia warrenana(?), and minute rounded columns of white calcite with cleavage normal to the length. White calcitic spherulites have grown in some of the fragments.
32	8.0	Shale, spherulitic as above. Contains a 1/2-foot bed of flesh-tan coarsely crystalline limestone 2 1/2 feet below the top, which is coquinal and contains ovoid gray sublithographic limestone concretions. From the coquina: FC 409, Ostrea sp., and Pachyteuthis fragments. Some shells are partly replaced by pyrite-limonite and others by finely crystalline white calcite.
31	5.5	Shale, gray-black, spherulitic as above.
30	0.5	Sandstone, green-white, very fine grained, calcite-cemented (almost a limestone), glauconitic, contains small limestone concretions, and forms a weak ledge.
29	0.5	Sandstone, green-gray, very fine grained, glauconitic, limy, cross-laminated, weathers into thin curved plates.
28	3.0	Shale, gray-black, spherulitic as above.
27	0.5	A zone of septarian limestone concretions, gray, sublithographic, whose septa are composed of pink-brown calcite crystals. The concretions are ovoid to oblately spheroidal and average 6 inches in diameter.
		Offset 200 yards east using Bed 27 as a key horizon
26	10.0	Claystone, gray-black, limy, spherulitic as above, with a few sandy layers. FC 408A, Oxytoma wyomingensis and Quenstedtia(?) impressions.
25	25.0	Shale and claystone, green-black, limy, silty, fissile to blocky, nonspherulitic. Contains a thin green sandy glauconitic finely crystalline limestone bed at the top, a lenticular gray micaceous limestone bed 10 feet below the top, and a thin zone of calcite-cemented siltstone concretions 15 feet below the top. From the limestone at the top: FC 408, Pachyteuthis sp., Ostrea sp., Camptonectes bellistriatus, Oxytoma wyomingensis fragments, foraminifers, and a coral(?) fragment. From a thin sandstone 3 feet above the base: Ostrea sp. fragments, worm(?) burrow casts, gray-black flat-sided Pentacrinus(?) sp. calcitic columns.
24	0.5	Sandstone, gray-green, very fine grained, lime-cemented, highly glauconitic, with many orange, yellow, and black grains, and mica flakes, cross-laminated. Makes a platy ledge. FC 407, Worm(?) burrows, Astarte packardi, Grammatodon(?) sp. Pleuromya newtoni(?), Tancredia bulbosa(?), T. warrenana(?), Cardioceras cf.

Bed	Feet	Description
		C. cordiforme, C. sp., and Pentacrinus(?) sp., all sand casts but the last which is composed of white calcite.
Offset 150 feet west using Bed 24 for a key bed.		
23	1.0	Shale, green, limy, fissile, with some sandy blocky claystone layers.
22	0.5	Limestone, gray-green, finely crystalline, sandy, abundantly glauconitic, with many yellowish grains and black, brown and green mineral flakes. FC 406, Ostrea, Meleagrinella curta, Pachyteuthis "densus", Grammatodon inornatus(?), and black, flat-sided calcitic pentagonal Pentacrinus sp.(?) columnar sections centrally perforate. These are less than 1 mm. in width, but are present in such quantity that they give the rock a dark pepper-flecked appearance. All forms listed, with the exception of Pachyteuthis and Ostrea are undersized, none being more than a few mm. in their largest dimension.
21	19.0	Siltstone, gray, weathers olive-green, limy, sandy, mixed with gray clay, glauconitic, blocky, soft, friable, appears to be a claystone on the outcrop. FC 405, Ostrea strigulecula(?), Pachyteuthis "densus", Astarte packardi, Grammatodon inornatus, Camptonectes(?) sp., Cardioceras cf. C. distans, C. sp., all poorly preserved casts or impressions.
	82.0	Total thickness of the Redwater shale
Contact of the Redwater shale with member B of the Sundance		
Offset east 150 feet.		
20	2.0	Sandstone, green-white, weathers gray-white, very fine grained, calcite-cemented, silty, glauconitic, with peppery black grains and flakes, and a few yellow-weathering grains, cross-laminated. Interstitial pyrite is present in aggregates whose bounding surfaces are irregularly rounded to ovaloid in form. The pyrite is weathering to limonite in concentric bands of various shades of brown. The ripple-marked surfaces of the rock are lined with biotite and muscovite flakes. The bed forms a relatively prominent ledge. FC 404, worm burrow(?) casts, some are annulated, others are smooth and spatulate-tipped, Tancredia bulbosa(?) casts, Pentacrinus asteriscus(?) poorly preserved white-pink calcitic fragments, echinoid(?) fragments. Subrounded, worn Pachyteuthis fragments are present in places on, or partly within, the topmost surface, but not in the ledge itself.
19	1.0	Shale, bluish-gray, limy, papery fissile at the top, gray-green very limy very clayey siltstone below.
18	7.0	Sandstone, green-white, very fine grained, lime-cemented, glauconitic; white calcitic ooliths with green clayey glauconite nuclei are common, as are brown calcitic ooliths. The texture is distinctly tapioca-like and resembles that of Bed 36 in miniature. The lower part of the interval is soft, massive and friable; the upper part is hard, cross-laminated and forms a ledge. Unidentifiable subrounded pelecypod fragments are present, some of which are partly replaced by pyrite-limonite(?).
17	3.0	Sandstone, green-white, weathers yellow to green-gray, very fine grained, lime-cemented, is a limestone in places, silty, sparsely glauconitic, coquinal, cross-laminated. Contains thin green shale partings and pyritic masses as in Bed 20. The texture is tapioca-like. Dark-brown to black organic stains are present in places. The bed forms a slabby ledge. FC's 401 and 402, Ostrea strigulecula fragments abundant, worm burrow(?) casts, Camptonectes extenuatus(?), Volsella formosa(?) fragments.
16	6.0	Interbedded thin blue-gray limy shale, gray-green calcite-cemented clayey siltstone and very fine grained sandstone in layers 1/2 inch to 2 inches thick. This interval contains a 2-inch green silty micaceous hard dense limestone 2 feet above the base. It is believed this limestone is the same as that of Bed 13 of the supplementary West Flat Top anticline section.
15	5.0	Redbed lithology predominant. Pink- to red-brown lime-cemented sandy micaceous siltstone, with thin layers of gray-white very fine grained sandstone, and gray-green silty limy claystone near the base.
14	9.0	Siltstone and claystone, yellow-green, limy, with two thin sandstone ledge-makers. One is 2 1/2 feet and the other 5 feet above the base. These ledge-makers are white, very fine grained, lime-cemented, and contain green clay-pebble inclusions.
13	7.0	Sandstone and siltstone intergrading, white to yellow-white, silty to fine-grained, limy, friable. Contains abundant poorly developed white calcitic ooliths with clayey green glauconite nuclei. The sandstone is shaly except for two harder cross-laminated layers 2 to 4 inches thick, one at the top and the other at the base, which form small ledges.
	40.0	Total thickness of member B
Contact of member B with the Lak(?) member of the Sundance		
12	1.5	Sandstone, white, fine-grained, limy above, very fine grained, limy, friable below.
11	106.0	Covered interval includes the lower part of the Lak(?) member, the Canyon Springs sandstone, the Nugget sandstone, and possibly the upper part of the Jelm.
Highest exposures of the upper member of the Jelm formation		
10	14.0	Sandstone, green-gray to yellow-gray, weathers green-yellow and brown, very fine to medium-grained, contains polished, rounded quartz and chert grains as well as subangular unpolished grains of the same composition. Dark mineral grains and clay impurities are numerous in the basal 4 feet. The rock is "trashy" in appearance, especially near the base. The very base of the bed contains a conglomeratic zone of clay pebbles and sandstone boulders up to 10 inches in diameter. The zone is from 4 to 8 inches thick and contains, in addition, an abundance of clay, large chert and quartz grains, and dark mineral grains and flakes. The bed weathers into rounded forms above and a vertical-faced ledge below. The sandstone is cross-bedded. The weakness inherent in the clayey nature of the conglomerate matrix has localized weathering, and the removal of the basal part leaves this bed (10) projecting as an overhanging ledge. Fragments of the conglomerate can be examined where they are cemented to the underside of the overhanging ledge.
9	1.0	Interbedded thin green-gray sandstone similar to the overlying, with gray-green siltstone and shale. The bed cuts

Bed	Feet	Description
		into the underlying bed.
	15.0	Total exposed thickness of the upper member of the Jelm
Contact of the upper member with the lower member of the Jelm		
8	5.0	Sandstone, mottled red-brown and gray-green, very fine to fine-grained, lime-cemented, with much clay and many dark mineral grains and flakes present. The top of this bed is irregular because of erosion and channelling.
7	9.5	Sandstone, green-white to pink-gray, weathers yellowish-white, very fine grained, lime-cemented, relatively free of impurities, cross-laminated. Clay pebbles are present in thin zones. The bed closely resembles in lithology some of the pebbles and cobbles of the conglomerate at the base of the upper Jelm. The sandstone weathers into a slabby ledge in the upper 1 1/2 feet, and to a rounded ropy-surfaced bare slope below.
6	5.0	Siltstone, green-white to pink-gray, weathers green-yellow, lime-cemented, clayey. The upper 2 feet forms a ledge, the lower 3 feet is softer and forms a reentrant.
5	1.5	Sandstone, green-white, very fine grained, lime-cemented. The few dark mineral impurities stand out conspicuously against the light background. The interval forms two sandstone ledges separated by 1 foot of green limy shale which forms a reentrant.
4	5.0	Shale, red-brown, sandy, noncalcareous, with two 2-inch hard white calcite-cemented sandstone ledges, one at the top and the other in the middle. Both weather gray-green, are cross-laminated, ripple-marked and resemble limestones on the outcrop. The upper ledge has various markings, casts, cracks, etc.
3	5.0	Claystone, red-brown, slightly limy, blocky, contains one bed of red-brown sandstone 4 inches thick which forms a small rounded ledge.
2	5.0	Shale, claystone, and red-brown siltstone. The siltstone is 4 inches thick, and is at the top of the interval. It is mottled gray-white and red-brown, weathers red-brown with green "eyes", is cross-laminated and makes a platy ledge. Of the remainder, the upper half is claystone and the rest is shale.
1	18.0	Sandstone, white, weathers gray-white, very fine grained, lime-cemented, with few dark mineral impurities. In places the matrix is calcitic and the cleavage faces sparkle on fresh fractured surfaces. The bed is thinly cross-laminated and makes a prominent rounded shoulder with a few reentrants near the top caused by the thin-bedded rather than massive character of the rock. The base of the bed is covered.
	54.0	Partial thickness of the lower member of the Jelm
Base of the measured section		

SECTION IV-A: WEST FLAT TOP ANTICLINE, SUPPLEMENTARY

The supplementary West Flat Top anticline section was measured on the west side of the Little Medicine Bow River, in the SE 1/4 NW 1/4 Sec. 14, T. 23 N., R. 79 W. It is from about 1/2 to 1 mile west of section IV proper. The Little Medicine Bow River flows west from section IV, then turns southwest, cuts through the Jelm hogback, turns west and continues in a series of bends, and then cuts south through the Sundance and Morrison formations and breaches the Cloverly hogback. In going from one section to the other it is necessary to ford the Little Medicine Bow River. Where the river turns south, erosion by tributaries has progressed northwestward up the valley between the Jelm and the Sundance formations, and has exposed the upper surface of the Nugget sandstone. This is the only exposure of the Nugget sandstone on the southwest flank of Flat Top anticline.

The strata in the supplementary section strike northwest and dip southwest. The dip ranges from 17 degrees in the Jelm formation to 10 degrees at the top of the Sundance formation. The section was measured to fill in the gaps in the description of the main section, where the Nugget sandstone and the basal portion of the Sundance are covered. Additional fossils were collected from the characteristically ledgy upper part of member B of the Sundance formation.

Redwater shale member of the Sundance formation, in part		
18	10.0	Shale, green to yellow-black, silty, limy, with numerous fragments of Pachyteuthis "densus". Note: A fragmentary specimen of Cardioceras cf. C. auroraense was found loose on the slope about 1 foot above unit 17.
Contact of the Redwater shale with member B of the Sundance		
17	3.0	Sandstone, gray-white above, green-white below, weathers brownish-white, very fine to fine-grained, sparsely glauconitic, has the texture of tapioca. Ooliths are common. Some are brown with no discernible nuclei, others are white with green clayey glauconite nuclei. The sandstone is thin-bedded ripple-marked and makes a ledge with blocky fracture in the upper part. The lower part of the bed is massive, cross-laminated, and reentrant. FC 4B02, Ostrea and Meleagrinella fragments partly replaced by blue-white chalcedony and hematite(?). Pachyteuthis fragments are found cemented to, or partly imbedded in the uppermost surface. No specimens found within the ledge itself.
16	2.0	Shale, blue-gray, limy, fissile
15	1.0	Sandstone, gray, weathers brown, very fine grained, lime-cemented, almost a limestone in places, with fractures lined with white calcite, cross-laminated. Forms a slabby ledge. FC 4B01, Meleagrinella sp. casts numerous, Tancredia transversa(?) casts, Trigonia sturgisensis casts few, large worm(?) burrow casts.
Offset eastward. Cross a small ravine and continue along the base of the Redwater shale slope to the top of the last exposure of member B just short of the Little Medicine Bow river valley. The offset distance is estimated to be 200 yards.		
14	7.0	Sandstone interbedded with silty shales. The sandstone is gray-white, very fine grained, calcite- to lime-cemented, makes numerous ledges with the reentrant shaly intervals mostly covered. The uppermost sandstone ledge-maker has cavities and fractures filled and lined with a brown-black tarlike highly viscous liquid. White and pink calcite crystals are also present in the cavities and fractures. Fossils are very abundant at this locality: FC's 4A04, 4A03, 4A02, 4A01, Lingula brevirostris lavender-gray phosphatic fragments numerous, Ostrea strigulecula and Plicatula(?) sp. fragments, worm(?) burrow casts, Camptonectes extenuatus(?) fragments, Tancredia corbuliformis(?) and T. inornata(?) casts, Meleagrinella curta casts, Trigonia sturgisensis casts, Mytilus(?) whitei fragments, Protocardium(?) sp. casts.

Bed	Feet	Description
13	5.0	Interbedded green-yellow clayey siltstone, dark-green fissile shale, and cross-laminated green sandy limestone in beds 1/4 inch to 4 inches thick. The interval makes a partly covered slope. The 4-inch green limestone layer at the base of this interval is believed to be the same as that reported in Bed 16 (2 feet above the base) of Section IV.
12	5.0	Shale, dark-green, limy, fissile, with a few thin sandstone beds. Forms a partly covered slope.
11	2.0	Siltstone, green-white, limy, soft, makes a partly covered slope.
10	3.0	Siltstone, green-gray, calcite-cemented, clayey, hard, makes a small ledge.
9	7.0	Interbedded siltstone, claystone, sandstone and limestone in layers 1/2 to 1 inch thick. The overall outcrop color is green-gray. Makes a partly covered slope.

Offset 200 feet eastward to the last rounded knoll exposed on the west side of the river valley. This knoll overlooks the isolated exposure of the Nugget sandstone described in the introduction to this section. The knoll is capped by:

8	0.5	Sandstone, gray-white, weathers brown, very fine grained, calcite-cemented, grades laterally into a sandy limestone; contains thin green shale partings, and forms a small resistant ledge. The upper surfaces are covered with irregular, obscure tracks, trails, burrow(?) casts, etc., among which salt(?) cube-casts up to 1/4 inch in size are conspicuous. It is believed this bed is the same as the ledge 5 feet above the base of Bed 14 of section IV proper.
7	3.0	Siltstone, blue-green, lime-cemented. The color is caused by the presence of clay in the form of streaks and inclusions, especially abundant in the upper part. The bed forms a reentrant.
6	5.0	Sandstone, white, weathers yellow-white, very fine grained, limy, cross-laminated. White ooliths with clayey green glauconite centers are common throughout. The upper 3 feet is massive, soft, contains limonitic aggregates, and forms a reentrant, while the lower part is hard, and forms a slabby ledge.
	42.5	Total thickness of member B

Contact of member B with the Lak(?) member of the Sundance

5	3.0	Sandstone, white, very fine grained, limy, has "tapioca" appearance. The lithology is quite similar to that of the overlying bed. The sandstone of this bed (5) has at its top a gypsiferous limonitic zone. The sandstone is massive and forms a reentrant.
4	1.0	Sandstone, white, very fine grained, limy, clayey, oolitic, cross-laminated. The ooliths are white calcite with green clayey glauconite nuclei. In addition, small numerous poorly preserved fossil fragments are present. The bed forms a weak slabby ledge.
3	3.0	Sandstone, yellow-white to green-gray, very fine grained, clayey, similar to the above but less limy; the upper part is more clayey than the lower, and contains at the top a zone of limonitic concretions associated with spongy cellular masses of selenite crystals. The crystal aggregates range up to 1 1/2 inches in diameter.
	7.0	Total thickness of the Lak(?) member

Contact of the Lak(?) member with the Canyon Springs sandstone member of the Sundance formation

2	10.0	Sandstone, yellow-white, weathers yellow to gray, very fine grained and limy. Medium and coarse rounded frosted grains prevalent in the lower half; are rare to absent in the upper half. The sandstone is soft, friable, and weathers into a ledge rounded at the top. The base is marked by a rust-brown 1-inch lime- and limonite-cemented layer whose surface is marked by current ripples wherever exposed. The lithology of this bed is identical to that of the underlying bed with the exception of the presence of ripple-marks and limonite.
	10.0	Total thickness of the Canyon Springs member

Contact of the Canyon Springs sandstone with the Nugget sandstone

1	60.0	Sandstone, pinkish- to yellow-white, weathers yellow-gray, very fine grained and limy. Medium to coarse quartz and chert grains, subrounded to rounded, frosted, are abundantly scattered throughout the finer-grained matrix, but are more numerous on laminae surfaces and traces. The sandstone is cross-bedded on a large scale and constitutes a bare sandy floor where the overlying valley alluvium has been stripped off by eroston. The base of the sandstone is covered by alluvium.
	60.0	Partial thickness of the Nugget sandstone

Base of the measured section

SECTION V: COMO BLUFF

The Como Bluff section lies in an area on the south limb of the west end of Como anticline, 6 miles east of Medicine Bow, Wyoming. The Jelm-Nugget sequence was examined in the SE 1/4 NE 1/4 Sec. 18, and the Sundance formation was examined in the SW 1/4 NE 1/4 Sec. 18, both in T. 22 N., R. 77 W.

The strata strike slightly south of west and dip southward. The dip ranges from 16 degrees in the Jelm to 14 degrees at the top of the Sundance formation. The basal Cloverly sandstone makes a conspicuous ridge to which the name Como Ridge has been applied (Pl. 3, A). The steep slopes and cliffs below the ridge have long been referred to as Como Bluff. Below the Cloverly formation the series of slopes and ledges is cut on the Morrison and Sundance formations. The Jelm-Nugget sequence makes a series of low ridges and cliffs. The lower member of the Jelm is best exposed at the west end of the anticline near the axis, a few hundred feet east of the Jelm-alluvium contact.

Morrison formation (in part)

36	10.0	Interbedded green-gray to ash-gray shale and brown sandstone.

Contact of the Morrison with member A of the Sundance formation

Bed	Feet	Description
35	10.0	Sandstone, yellow-white, weathers yellow-brown, fine-grained, calcite-cemented, with cleavage faces giving a sheen to the rock in places. Glauconite is scarce. The lower part is slabby, thin-bedded and contains smooth yellow clay layers on the ripple-marked bedding planes. The upper part shows faint indications of cross-lamination.
	10.0	Total thickness of member A

Contact of member A with the Redwater shale member of the Sundance

34	26.0	Shale, blue-gray, limy, fissile, with numerous thin beds of cross-laminated limy sandstone and sandy limestone. The whole is abundantly glauconitic. From the sandstone and limestone: FC 5B12, Tancredia corbuliformis(?) and Pleuromya newtoni(?) casts, Oxytoma wyomingensis, Meleagrinella curta, Camptonectes(?) sp. and Pachyteuthis sp. fragments.
33	2.0	Shale, blue-gray, limy, smooth, flaky, interbedded with thin layers of profusely glauconitic green-gray limy sandstone. FC 5B11, Ostrea strigulecula(?), Ostrea sp. and Camptonectes bellistriatus(?) fragments, Astarte packardi cast, fish(?) tooth. The sandstone layers also contain numerous unidentifiable pelecypod fragments, fish(?) teeth and fish scales(?).
32	2.4	Shale, blue-gray, same as above, with an 8-inch bed of gray very fine grained highly glauconitic sandstone at the top.
31	8.0	Claystone, gray, very limy, silty, with many thin layers of green-gray limy silty cross-laminated sandstone in the top 1 foot. The entire interval contains green glassy grains of glauconite(?) easily powdered white with a knife blade. One foot below the top of the bed is a zone of gray sublithographic limestone concretions. From the top 1 foot of this interval: FC 5B09, Ostrea strigulecula fragments, Astarte packardi, Tancredia(?) sp., Meleagrinella curta, Cardioceras cf. C. auroraense and Cardioceras(?) sp. casts. From the concretions: FC 5B08, Oxytoma wyomingensis and Grammatodon inornatus shells a few mm. in length.
30	3.6	Sandstone, gray, very fine grained, almost a siltstone, limy, with olive-gray shale partings that weather blue-gray. The presence of varicolored and black mineral grains and flakes gives the sandstone a "trashy" appearance.
29	3.0	Shale, blue-gray, weathers with a yellowish tinge, limy, uniform, with a subconchoidal fracture.

Offset about 1/4 mile west to the steep narrow gully formed by the westernmost tributary of the main stream in Section 18. The main stream referred to drains northwest through a gap in the hogback made by the steeply inclined beds of the west end of the north limb of Como anticline. This gap is known as Robber's Roost.

28	11.5	Siltstone, yellow-gray, weathers yellow-buff, limy, sandy, with an abundance of gray clay. The bed is highly glauconitic, massive, and fractured into blocks from 1 inch to 6 inches long. From a coarse blocky zone near the top: FC 507, Pachyteuthis "densus", Astarte packardi, Pleuromya cf. P. newtoni, Pholadomya sp., Dentalium subquadratum, Proeconia sp., Cardioceras wyomingense, C. cf. C. cordiforme, C. cf. C. stantoni, Goliathiceras cf. G. suspectum, Goliathiceras(?) sp.. All are silt casts with the exception of the minute scaphopod Dentalium subquadratum, which is preserved as chalky perfectly square columns whose circular living chambers are filled with clear calcite crystals.
27	4.5	Interbedded yellow- to gray-green limy siltstone and green shale with gray very fine to fine-grained lime-cemented glauconitic sandstone ledges. The sandstone grades into sandy limestone in places. Locally, fossil fragments are numerous, making the sandstone a near-coquina. In addition the sandstone contains numerous red fine to medium grains of altered glauconite(?), white calcitic ooliths with clayey green glauconite centers, and pyrite-limonite cubes up to 3/4 inch in size. The siltstone and shale form reentrants. From a sandstone ledge 1 1/2 feet above the base: FC 506, Meleagrinella curta, Camptonectes extenuatus(?), Pachyteuthis "densus", foraminifers, Oxytoma wyomingensis. All are fragments except the foraminifers. Pyrite-limonite has partly replaced some of the shell fragments. One flat-sided pentagon of pyrite-limonite was observed, probably a pseudomorph after Pentacrinus sp. stem fragment.
26	1.0	Shale, yellow-gray, weathers olive-gray, limy, uniform, flaky.
25	1.0	A layer of gray well rounded pebbles, cobbles and boulders of oolite up to 2 feet in diameter (Fig. 3). The pebbles and smaller cobbles are incorporated in a 3-inch coquina. The coquina surrounds the lower portions of the larger cobbles and boulders. The upper portions of the larger cobbles and boulders are embedded in the lower part of Bed 26. The coquina is gray-yellow, sandy, limy, oolitic, "trashy", conglomeratic, and contains a few black chert pebbles and green clay pebbles. From the coquina: FC 504, Pachyteuthis "densus" fragments worn almost round, Ostrea sp. partly silica-replaced, fish(?) teeth, Cidaris bellefourchensis spines, Camptonectes sp., Meleagrinella curta, Pentacrinus asteriscus, P. sp., Mytilus(?) sp., and spiral Serpula(?) borings in some of the Ostrea fragments. The oolite fragments are gray, hard, dense, lime-cemented. The ooliths are composed of as many as 4 concentric layers of pyrite and white calcite. The nuclei are composed of glauconite, pyrite, magnetite crystals, and rounded quartz grains. Most of the ooliths are spherical but some are quite elongate. Large Ostrea shells, O. comoensis(?), O. densa(?), are cemented to the surfaces of the oolite boulders. Smaller Ostrea shells, probably the form identified by Logan (1900) as O. soleniscus(?), are attached to the internal surfaces of the larger shells. The normally flat-lying shale of Bed 26 is compaction-folded over the top of the boulders. On the north limb of Como anticline this part of the Sundance formation is well exposed in several places in the gullies east of and tributary to the main stream in Sec. 18. There the equivalent of Bed 25 is a 4-inch gray to green-yellow limestone-coquina which is sandy, glauconitic, oolitic and conglomeratic. The coquina contains pyrite-limonite cubes, rounded waterworn Pachyteuthis pebbles, and normal-appearing Pachyteuthis individuals. Some of the Pachyteuthis pebbles are replaced by blue-white chalcedony. A typical oolith: chalky white calcite nucleus enveloped by blue-white chalcedony, in turn surrounded by pyrite, with an outermost layer composed of powdery white minutely crystalline calcite. The rock has vertical joint-fractures lined with blue-white chalcedony. A set of fractures parallel to the bedding cuts through the vertical fractures and is lined with white finely crystalline calcite. The calcite and chalcedony of the fractures appears to be the same as the material of which some of the ooliths are composed in part. This 4-inch coquina conformably overlies a 2-foot bed of gray dense, hard oolite. This oolite is the equivalent of the oolite boulders etc. of Bed 25. The oolite bed is highly fossiliferous: FC 5A01, Camptonectes bellistriatus, Meleagrinella curta, Ostrea densa(?), O. comoensis(?), O. soleniscus(?) of Logan, O. strigulecula, Oxytoma wyomingensis, Tancredia corbuliformis(?), Pachyteuthis "densus", Trigonia quadrangularis, scaphopods(?), coral(?) fragments, Pentacrinus asteriscus, vertebrate(?) fragments, and doubly spiraled Serpula borings in some of the shell fragments.

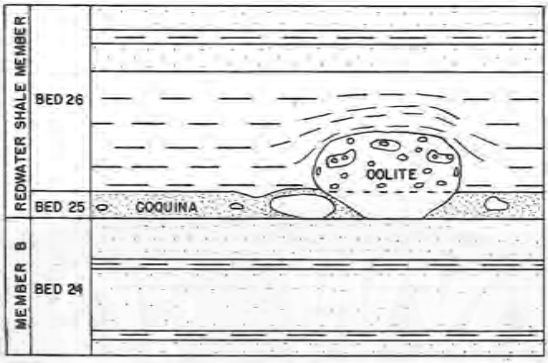


Figure 3. - Diagram of contact of member B with the Redwater shale member of the Sundance at Como Bluff.

Bed	Feet	Description
		Continuation of the main section:
	63.0	Total thickness of the Redwater shale
Contact of the Redwater shale with member B of the Sundance		
24	1.0	Sandstone, gray, weathers yellow-tan, very fine grained, lime-cemented, grades into a sandy limestone in places, ripple-marked, cross-laminated, with a few inconspicuous glauconite grains and mica flakes making up most of the impurities present. The interval contains a thin green shale bed, and makes a ledge. Pachyteuthis, Ostrea and Pentacrinus asteriscus fragments, rounded and waterworn, are cemented to, or partly embedded in the uppermost surfaces of the ledge, but are not present within the ledge itself.
23	1.3	Sandstone, dark green-gray, weathers rusty-tan, very fine grained, lime-cemented, with finely disseminated pyrite flakes, which upon weathering give the rock its surface color. Several very thin green uniform fissile shale partings are present. The sandstone is cross-laminated, hard, and makes a lenticular ledge whose upper surface contains oscillation ripple-marks.
22	0.5	Sandstone, gray, weathers yellow-tan, very fine grained, calcite-cemented, sparsely glauconitic, ripple-marked, cross-laminated. Yellowish grains weathering rusty-yellow give the rock its outcrop color. The bed forms a ledge. FC 502, Tancredia inornata(?), Camptonectes extenuatus(?), Meleagrinella(?) sp., Mytilus(?) sp., and worm(?) burrow casts, poorly preserved.
21	3.8	Sandstone, white, weathers yellow, very fine grained, lime-cemented, and contains dark mineral impurities. The lower 2 feet is massive, while the upper part is very thin-bedded with numerous green shale partings near the top. The bed is ripple-marked throughout and contains worm(?) burrow casts.
20	2.3	Sandstone, white, weathers yellow-white, very fine grained, soft, friable. The interval is massive below, and contains numerous thin beds of green limy shale. The whole forms a reentrant.
19	1.8	Sandstone, green- to pink-white, weathers gray-white, fine- to medium-grained, calcite-cemented, contains brown and white ooliths, with green clayey glauconite nuclei. A few conspicuous varicolored and black medium mineral grains are present. The interval is in beds 2 to 6 inches thick, and forms a hard ledge.
18	3.3	Sandstone, yellow-white, weathers yellow-gray, fine-grained, with many dark and light green clayey glauconite grains present, which resemble the nuclei of the white calcitic ooliths described from other beds of this section. The sandstone forms two ledges and two reentrants, the upper part is reentrant and contains thin yellow-green shale partings.
17	9.0	Shale and siltstone in layers 1/4 to 1/2 inch thick. The shale is blue-green, weathers yellow, limy, uniform, flaky. The siltstone is green-gray, calcite-cemented, hard, lenticular, and is invariably ripple-marked and cross-laminated. The shale forms a slope.
16	1.0	Redbed. Sandstone, dark red-brown, very fine grained, very limy, very silty, very clayey. Resembles a bed of massive blocky claystone on the outcrop. The bed forms a slope.
15	16.0	Siltstone, green, clayey, limy, soft, with many thin layers of green-white very fine grained sandstone, especially numerous in the upper 4 feet. Hard thin rounded brown limonitic sandstone nodules with obscure casts and impressions are abundant throughout. Five feet below the top of the interval is a zone of fibrous to platy-tabular perfectly developed selenite crystals up to 1 1/2 inches in length. The bed forms a partly covered slope.
14	2.5	Sandstone, gray-white to green-gray, very fine grained, calcite-cemented. Yellowish-green minute glauconite grains, red-brown pyrite-limonite cubes, and white finely crystalline calcite veinlets are common. The brown

Bed	Feet	Description
		ooliths are composed either of brown calcite throughout or have white calcitic nuclei. The green-brown ooliths owe their color to their green glauconite nuclei. The brown calcitic fossil fragments are composed of the same material as the external shell of the ooliths. The sandstone grades laterally and vertically into an oolitic limestone, forms a slabby ledge and rests disconformably on the underlying unit. FC 501, Meleagrinella curta(?) comprises the bulk of the fragments present; other fossils are unidentifiable.
	44.5	Total thickness of member B
Contact of member B with the Lak(?) member		
13	4.0	Sandstone, green-white, fine-grained, sugary textured, limy, clean-looking; round clayey glauconite grains similar to the nuclei of ooliths described in overlying units are common. The sandstone is massive, soft, cross-laminated and forms weak ledges and reentrants. The cross-lamination is truncated at the top by the overlying slabby ledge of Bed 14.
12	2.0	Sandstone, yellow-white, weathers yellow-tan, very fine grained, limy, contains a thin zone of white finely crystalline calcitic masses up to 3 inches thick, associated with green-yellow limy shale, and small imperfect selenite crystals. Small limonitic concretions are numerous and scattered throughout the sandstone. The bed is soft, massive and forms a sandy slope. The base of the sandstone is covered and the rest of the thickness is given in the description of Bed 11. The zone of shale-calcite-selenite is 2 feet below the top of the sandstone and was used as a key bed in offsetting.
Offset about 1/2 mile eastward along strike to approximately the NE 1/4 SE 1/4 NE 1/4 Sec. 18, T. 22 N., R. 77 W. At the offset location the equivalent of Bed 13 makes a ledge that caps a 12-foot sandy slope cut on a bed that is the equivalent of Bed 12. The key bed is found to be 3 feet below a ledge equivalent to the ledge of Bed 13, and the section is continued from the key bed downward.		
11	7.0	Sandstone, a continuation of Bed 12, varies from 5 to 9 feet in thickness, possibly because the upper surface of the Canyon Springs sandstone, on which it was deposited, is irregular.
	13.0	Total thickness of the Lak(?) member
Contact of the Lak(?) member of the Sundance formation with the Canyon Springs sandstone		
10	6.0	Sandstone, yellow-white, weathers gray, very fine grained. Large polished well rounded quartz and chert grains are common throughout, and are more numerous near the base. The sandstone is massive, but has a bedded appearance because of the presence of parallel horizontal laminae 4 to 8 inches thick. The sandstone has weathered into rounded isolated remnants and a 6-foot ledge, which rises from the bare upper surface of the cliff proper to the slopes of the Sundance (Pl. 3, A).
	6.0	Total thickness of the Canyon Springs sandstone
	136.5	Total thickness of the Sundance
Contact of the Canyon Springs sandstone member of the Sundance with the Nugget sandstone		
9	60.0	Sandstone, same as the above, but contains abundant large rounded quartz and chert grains concentrated along the laminae surfaces and traces. The interval is cross-bedded on a large scale, and forms a massive rounded cliff. The change in lithology from this to the underlying unit is gradational within a few feet. (See also section V-B; Como Ridge, Supplementary).
	60.0	Total thickness of the Nugget sandstone
Contact of the Nugget sandstone with the upper member of the Jelm formation		
8	5.0	Sandstone, green-gray, weathers green-yellow to gray, very fine to coarse-grained, lime-cemented, contains numerous angular to well rounded medium to coarse quartz and chert grains, cross-bedded. Abundant green and black mineral grains and flakes in conjunction with numerous clay pebbles give the rock a "trashy" appearance. The base is a conglomerate and contains pebbles, cobbles and boulders of siltstone, sandstone, and very sandy limestone; the largest noted was 8 inches in diameter. Except for the apparent absence of fossil wood and bone fragments, the general lithology of the conglomerate is similar to that of previous sections. The top of this bed is chosen arbitrarily, inasmuch as there is a complete gradation in lithology from this to the overlying bed. The sandstone makes a slabby ledge or low ridge.
	5.0	Total thickness of the upper member of the Jelm
Contact of the upper member with the lower member of the Jelm		
7	3.5	Claystone, green, and limy above, red-brown and noncalcareous below, very silty throughout. The bed is reentrant.
6	2.0	Sandstone, white, weathers green-yellow, fine-grained, limy, soft, friable. The green tinge is caused by the presence of green clay. The interval forms a slope.
5	5.0	Shale, cocoa-brown to mottled red-green, noncalcareous, interbedded in the upper part with green limy shale and siltstone. Forms a slope.
4	13.0	Sandstone, white, weathers gray-yellow, very fine grained, lime-cemented. Many dark mineral grains and flakes give the rock a greenish tinge. The top 2 feet is softer and forms a reentrant. The middle is cross-laminated to bedded in 8-inch to 4-foot layers, ripple-marked, and forms a rounded shoulder. The basal 1 foot is soft, silty, more yellowish in color and forms a reentrant.
3	2.3	Sandstone, white to green-white, red-brown in the upper few inches, very fine to fine-grained, silty, limy. The lower part forms a slabby ledge.
2	25.0	Claystone, shale and sandstone interbedded, red-brown to mottled red-green, with a varying lime content. The bed contains numerous thin hard calcite-cemented siltstone ledges that resemble limestone ledges on the outcrop.
1	6.0	Sandstone, gray-white, weathers green- to yellow-white, fine-grained, limy, soft, friable, makes a rounded

Bed	Feet	Description
		shoulder.
		The base of the sandstone is covered.
	57.8	Partial thickness of the lower Jelm

Base of the measured section

SECTION V-A: COMO BLUFF, SUPPLEMENTARY

In May, 1948, the Como Bluff section was briefly revisited and member A of the Sundance formation was reexamined at a locality about 1/4 mile west of the north-south fence on the Carbon-Albany county line. The outcrop in question is in the NE 1/4 Sec. 17, T. 22 N., R. 77 W., about 1 mile east of where member A was examined in the description of the Como Bluff section, proper.

Morrison formation (in part)

5	10.0 +	Shale, gray-green, limy, with thin beds of sandstone and limestone that make numerous small hard ledges.

Contact of the Morrison formation with member A of the Sundance formation

4	4.0	Sandstone, yellow-gray, weathers rusty-buff, very fine grained, lime- and calcite-cemented. The matrix has a weathered clayey appearance in places. Glauconite grains are rare but present. Black mineral grains and aggregates are scattered throughout. The texture has the appearance of tapioca. The fresher part of the rock is yellow-white, calcite-cemented, with cleavage faces giving a sheen to fresh fractures. The bed is ripple-marked, slabby, thin-bedded, has coarse calcite crystals along the vertical fractures and forms a ledge.
3	3.0	Shale, gray-green, moderately limy, very sandy, contains a few definite glauconite grains. The shale contains beds of yellowish- to greenish-white sandstone up to 1/4 inch thick. The lithology of these sandstone layers is indistinguishable from that of the beds above and below Bed 3. Glauconite grains are more numerous in the sandstone than in the shale, but are relatively scarce. In the shale there also is a layer of white amorphous calcite 1/4 inch thick which encloses and has partly replaced some clear quartz masses and white oolitic chalcedony.
2	3.0	Sandstone, yellow-buff, weathers tan to orange-buff, very fine grained, identical to Bed 4, but contains more numerous definite glauconite grains than does Bed 4. Ripple-marks are predominantly of the superimposed gridiron pattern similar to those of Bed 37 of member A of Section II. The sandstone forms a slabby ledge.
	10.0	Total thickness of member A

Contact of member A with the Redwater shale member of the Sundance formation

1	10.0	Shale, gray-black, limy, glauconitic, contains numerous thin lenticular sandstone and limestone beds that are fossiliferous. Pachyteuthis "densus" is abundant throughout. The Redwater shale member is not well exposed at this locality.

Base of measured section

SECTION V-B: COMO BLUFF, SUPPLEMENTARY

In May, 1948, the Como Bluff section was revisited and the Jelm formation was briefly inspected with regard to lithology, and the thicknesses of the various beds were estimated. The Jelm was examined along the east bank of the main stream in Section 18 which at this locality cuts northwestward directly across the west end of Como anticline.

Nugget sandstone (in part)

11	50.0 +	Sandstone, yellowish-white, weathers gray, very fine grained, lime-cemented, cross-laminated on a large scale. Forms a massive rounded cliff.

Contact of the Nugget sandstone with the upper member of the Jelm formation

10	4.0	Sandstone, greenish-gray, very fine grained, lime-cemented, "trashy", thin-bedded. Mica and chlorite flakes are quite numerous. Some of the green grains appear to be glauconite. Some of the mineral grains are altering from a black to a rusty-brown color. Forms a slabby ledge.
9	6.0	Shale, pale bluish-green, noncalcareous, uniform, platy, with subconchoidal fracture. The color is of an unusual shade.
8	4.0	Sandstone, greenish-white, weathers gray, fine-grained, calcite-cemented, with many green and black mineral grains and impurities, cross-bedded. Some of the green grains appear to be glauconite. The base is conglomeratic, contains pebbles and cobbles of red-brown claystone, yellow-gray siltstone and sandstone. Forms a slabby ledge.
	14.0	Total thickness of the upper member of the Jelm

Contact of the upper member with the lower member of the Jelm

7	12.0	Redbeds. Red-brown claystone and siltstone. Forms a slope.
6	18.0	Sandstone, gray-green, stained red-brown in places, limy, thin- to irregularly bedded. Forms a weak ledge.
5	25.0	Redbeds similar to Bed 7. Forms a slope.
4	5.0	Sandstone, gray-white, weathers brown-white. Forms a massive rounded ledge.
3	20.0	Shale and sandstone, green-gray, thin-bedded. There is a 1/4- to 1/2-inch chert layer at the top which has a rough surface because of irregular concentric petaloid growths. These chert growths in places are attached to the chert layer by thin stems and are easily broken off. The slope has numerous broken-off rosettes lying on it. The rosettes are mostly white, some pink in color and attain a diameter of 3/4 inch. The thickness averages

Bed	Feet	Description
		somewhat less than 1/4 inch. The parent chert bed appears to be partly replaced or intergrown with white finely crystalline calcite, and has a slaty ring when struck with a hammer. See chert rosettes in Bed 14, Section III.
2	30.0	Sandstone, gray, with conspicuous ovaloid rusty-brown limonitic concretions up to 2 feet in length and 1/2 foot in thickness. The sandstone makes a cliff whose surface is rounded, wind-pocked, and whose upper 5 feet is cross-bedded and slabby.
	110.0	Estimated total thickness of the lower member of the Jelm
Contact of the lower member of the Jelm formation with the Chugwater formation		
1	20.0 +	Redbeds. Red-brown claystone with thin beds of gray-green siltstone. The remainder of the Chugwater is not exposed at this locality.
Base of the section		

SECTION VI: CENTENNIAL

The Centennial section lies in an area 1/2 mile due west of the town of Centennial. It is located in the SW 1/4 SW 1/4 NW 1/4 Sec. 3, T. 15 N., R. 78 W. The strata strike north and dip east. The dip ranges from 40 degrees in the Jelm to 45 degrees at the top of the Sundance. Owing to the high dips, the area is of low relief. The section was measured across a shallow valley trending north-south, bounded on the west by the dip slope and ridge made by the upper member of the Jelm formation and on the east by the low ridge made by member A of the Sundance formation (Pl. 3, B). The line of section lies on the north side and within a few feet of an east-west barbed-wire fence.

Exposures for the most part are poor, and fresh specimens of the rocks are difficult to obtain even with much digging.

Morrison formation in part		
25	20.0 +	Shale, light yellowish-green, limy, with lenticular thin yellow sandy zones.
Contact of the Morrison with member A of the Sundance formation		
24	8.0	Sandstone, white, weathers gray-yellow to rusty-brown, medium-grained, cemented by clear calcite crystals. Many medium to coarse red, orange, gray, purple and black mineral grains are present. The bulk of the sand grains are subrounded to well rounded, pitted and frosted. In addition, clayey green glauconite grains are present, identical to the nuclei of the white calcitic ooliths found in rocks of the previous sections and in the sandstone of Bed 20 of the present section. Except for the absence of numerous large grains of glauconite, this sandstone is practically identical in lithology to that of Bed 20 below. The sandstone is thin-bedded, weathers into ripple-marked slabs 1/2 inch to 4 inches thick, and makes a low ridge and a short dip slope. Pachyteuthis "densus" fragments were found lying loose at the very crest of the ridge and on the dip slope. Some of them have sand grains partly embedded in their outer surfaces associated with patches of white calcitic matrix. These could have come from one of two beds; either Bed 24 or Bed 20. One rock slab was found loose near the base of this sandstone that contained poorly preserved fragments of Ostrea sp. The lithology of the Ostrea-bearing slab matches that of Bed 24.
	8.0	Total thickness of member A
Contact of member A with the Redwater shale member of the Sundance		
23	1.5	Shale, blue-green, weathers gray-green, limy, silty, contains a 1-inch layer of blue-white banded to oolitic chalcedony surrounded and partly replaced by chalky white calcite. The calcite-chalcedony layer is at the base of the shale.
22	3.5	Shale, blue-green, weathers gray-green, limy, silty, glauconitic, contains scattered nodules of fossiliferous siltstone. The shale along with the overlying and underlying beds forms a partly covered slope. FC 606, Pachyteuthis "densus" numerous throughout, and poorly preserved chalky fragments of Meleagrinella curta(?).
21	5.0	Siltstone, buff-gray, limy, highly glauconitic. The gray color is caused by the presence of much clay. The bed contains a few well rounded fine clear quartz grains. White chalky fossil fragments are numerous but poorly preserved. The unit makes a grass-covered slope. FC 605, Meleagrinella curta(?) fragments. Other forms are represented, but are unidentifiable. Some of the fossil fragments are penetrated by pyrite-limonite cubes.
20	1.0	Sandstone, white, weathers gray in general, rusty-orange in places, medium-grained, cemented by clear medium-textured calcite crystals. Medium dark green botryoidal clayey grains of glauconite are common. Owing to the presence of glauconite and numerous other red, orange, gray, purple and black mineral grains the rock has a salt and pepper aspect. White multiple-shelled chalky ooliths with clayey green glauconite centers are present in limited numbers. Rusty-orange patches and films are associated with unidentifiable fossil fragments. The lithology of the sandstone is remarkably similar to that of Bed 24. The sandstone forms a slabby ledge. FC 604, large flattened worm(?) burrow casts of blue-gray clay, Ostrea sp., Meleagrinella curta, Camptonectes(?) sp., Oxytoma(?) sp., Lingula brevirostris, Pachyteuthis "densus" and Pentacrinus(?) sp. fragments. The Pachyteuthis specimens are a pale translucent gray-brown in contrast to their usual brown-black color, and the remnants of their phragmocones are filled with white calcite crystals and a few large rounded clear quartz grains.
	11.0	Total thickness of the Redwater shale
Contact of the Redwater shale with member B of the Sundance		
19	5.0	Shale, blue-green, weathers yellow-green, limy, silty, micaceous, forms a covered slope.
18	6.0	Mudstone, green-gray, weathers dull brown-gray, limy, very silty, very clayey, sparsely glauconitic, micaceous, soft, friable. The upper part is practically a siltstone yellow-gray in color, and contains many dark mineral grains and flakes, and white calcitic green-centered ooliths. The bed forms a deeply weathered covered slope. FC 603, Lingula brevirostris fragments, worm(?) burrow and other unidentifiable casts.
17	0.5	Sandstone, gray-white, weathers yellow-white to tan, very fine to fine-grained, lime- and calcite-cemented. Contains white calcitic ooliths with clayey green glauconite centers, and a few brown-shelled white-centered ooliths.

Bed	Feet	Description
		Dark mineral grains are few and form irregular aggregates. The rock is brown-stained by organic matter in places. The sandstone is cross-laminated, ripple-marked and forms a small slabby ledge. FC 602, worm(?) burrow casts are numerous and of many different varieties, Tancredia corbuliformis(?), T. warrenana(?), Trigonia sturgisensis(?), all are poorly preserved sand casts.
16	2.0	Shale, gray-green, weathers olive-drab, limy, uniform, waxy, forms a reentrant slope.
15	0.5	Sandstone, green-white, weathers yellowish, fine-grained, limy, glauconitic, with a few dark mineral grains present. The sandstone is soft, quite friable, and makes a weak ledge. FC 601, worm(?) burrow casts numerous and of many kinds, Lingula brevirostris and Meleagrinella curta(?) poorly preserved fragments, and Pentacrinus(?) stem fragments.
14	1.0	Shale, blue-gray, weathers greenish-gray, limy, smooth, with many very thin sandstone beds similar in lithology to that of the overlying sandstone. The thin sandstone beds have a barely perceptible pink tinge in places.
13	1.0	Redbeds. Sandstone and claystone, red-brown, limy, has a green zone at the top. The unit forms a slope.
12	4.0	Sandstone, white, weathers yellowish, very fine to fine-grained, lime-cemented, has "tapioca" appearance in places, contains white calcitic ooliths with clayey green glauconite centers. Large rounded polished medium quartz grains are sparsely present. The sandstone underlies the alluvium at the eastern edge of the valley floor.
11	2.0	Sandstone and shale thinly interbedded. The sandstone weathers or is stained lavender, very fine grained, limy, soft. The shale is blue-gray, limy, uniform. Forms a part of the covered valley floor.
10	2.0	Sandstone, purplish-lavender (color may be inherited or due to weathering or staining) with numerous lenticular thin creamy-yellow layers. The sample was obtained from a hole dug into the valley floor and is probably quite badly weathered. The following is descriptive of the yellow portion: very fine grained, limy, contains white calcitic ooliths with clayey green glauconite centers, and minute white calcitic plates that are probably fossil fragments.
9	2.0	Shale, gray-green, slightly limy, finely interlaminated with gray-white very fine grained very limy sandstone that contains few dark mineral impurities. The bed underlies part of the valley floor.
	26.0	Total thickness of member B
	45.0	Total thickness of the Sundance
Contact of member B of the Sundance with the Nugget sandstone		
8	3.0	Sandstone, light-red, very fine grained, very limy, silty, clayey, friable, badly weathered. The remainder of the bed is covered by vegetation and the alluvium of the valley floor. Bed 8 may be the upper part of the Canyon Springs sandstone.
7	107.0	Sandstone completely covered except for an isolated exposure near the base of the Jelm dip slope about 200 feet north of the east-west fence in the area. The exposure measures 4 feet wide by 8 feet long. From a specimen of the exposure: sandstone, yellow-brown, fine-grained, limy. Medium to very coarse polished subrounded to well rounded quartz and chert grains are numerous, and abundant along laminae traces. The smaller of these grains are usually well rounded to spherical, the larger ones usually are subrounded, rarely well rounded. A few medium grains of subangular white feldspar were observed. The outer surfaces of the feldspar grains are weathered to a soft white clayey material, while the centers are still fresh. The brownish tinge in the outcrop is believed to be caused by organic matter. The sandstone is cross-bedded, massive, and friable. The sandstone of this limited exposure is judged to be but a few feet above the Nugget-Jelm contact. The contact of the Nugget sandstone with the upper member of the Jelm formation is chosen on the basis of the difference in topographic expression as explained in previous sections.
	110.0	Total thickness of the Nugget sandstone (may include Canyon Springs sandstone at the top)
Contact of the Nugget sandstone with the upper member of the Jelm formation		
6	16.0	Sandstone, green- to pink-gray, fine- to medium-grained, lime-cemented, hard, cross-bedded. The greenish cast to the rock is caused by numerous green and black mineral grains and flakes. Red-brown clay pebbles are common, and more numerous near the bottom. Numerous medium well rounded polished quartz and chert grains are scattered throughout. The contact with the underlying bed is gradational. The interval forms a ridge and a vegetation-covered dip slope.
5	5.0	Sandstone, pink- to red-brown, mottled green in places, medium- to very coarse grained, lime-cemented, has a "trashy", conglomeratic appearance. Red-brown clay pebbles are numerous throughout, abundant near the base. Large well rounded frosted quartz and chert grains are abundant. The base contains a conglomerate composed of clay pebbles and hard sandstone cobbles. Small white worn fossil bone fragments are common. The sandstone becomes increasingly "trashy" and conglomeratic from the top downward. Bed 5 forms the core of the ridge crest.
4	3.0	Sandstone, green to gray-white, fine-grained, calcite-cemented, cross-bedded; has an impure, slightly "trashy" aspect because of numerous mica and chlorite flakes. Some of the green color is caused by disseminated green clay in the matrix. The bed contains a few green clay pebbles. The sandstone forms a ledge that cuts into the underlying unit.
	24.0	Total thickness of the upper member of the Jelm
Contact of the upper member with the lower member of the Jelm		
3	33.0	Shale and claystone, red-brown, limy, sandy, micaceous, fissile to blocky in fracture. The interval forms a partly covered slope and varies in thickness from 1 to 3 feet because of the channelling of the overlying unit.
2	2.0	Sandstone, yellow- to pink-white, fine-grained, lime-cemented, with numerous green and black mineral flakes coating the laminae surfaces. In general the rock has a fairly well sorted, clean sparkly somewhat sugary textured appearance. The bed is massive, cross-laminated, and forms a rounded ledge.

Bed	Feet	Description
1	1.0	Shale, red-brown, limy, colored green at the contact with the overlying sandstone. The remainder of the Jelm formation is covered by a grassy meadow.
	36.0	Partial thickness of the lower member of the Jelm formation

Base of the measured section

SECTION VII: JELM

The Jelm section was measured across the west limb of a small anticline about 1/4 mile east of Jelm. The approximate location is the SW 1/4 NE 1/4 Sec. 35, T. 13 N., R. 77 W. The area is easily accessible from the Woods Landing-Jelm road. (See Stop 14, p. 34, Guidebook of First Annual Field Conference of the Wyoming Geological Association, 1946).

A small creek that flows westward along the southern margin of the locality crosses the road a few feet from the gate of the Lazy J Ranch. The crossing is marked by a small bridge. By following the left bank of the creek eastward for about 100 yards, the measured section, which lies about 100 feet north of the creek, can be located. The top of the section is marked by short nearly vertical walls made by member A of the Sundance formation.

The strata in the area strike northward and dip westward. The dip ranges from 55 degrees at the top of the Chugwater to 79 degrees at the top of the Sundance.

The section is poorly exposed, and the thickness measurements were made difficult because of the numerous small faults in the area. The thicknesses were found to total 387 feet from the top of the Chugwater formation to the top of the Sundance formation. The thicknesses given below for the Nugget sandstone and the Jelm formation are adjusted by visual estimation made on a brief revisitation of the section in May, 1948.

This and the remaining measured sections lie within the type Jelm area.

Morrison formation (in part)

13	10.0+	Claystone, green and mauve-brown, limy, sandy, contains fragments and pebbles from the underlying bed up to 1/4 inch in diameter near the base.

Contact of the Morrison with member A of the Sundance formation

12	4.0	Sandstone, white, weathers gray-buff, fine-grained at the top, very coarse grained at the base, cemented by medium to coarse clear calcite crystals that sparkle on fresh-fractured surfaces. Orange, red, gray, and clear angular to well rounded and polished medium to very coarse quartz and chert grains are abundant. The base has a conglomeratic appearance and contains chert pebbles up to 1/4-inch diameter. The laminae surfaces weather to a rusty yellow-orange color. In addition, the larger grains are concentrated on the surfaces of the laminae, together with sporadic small green clay pebbles. The sandstone is laminated, ripple-marked, weathers into 2- to 4-inch slabs, and forms a near-vertical ledge.
	4.0	Total thickness of member A

Contact of member A with member B of the Sundance

11	0.5	Shale, blue-green, limy, silty, contains at the base a 2-inch layer of orange-white and blue-white banded chalcedony, intergrown with and partly replaced by coarsely crystalline clear and white calcite.
10	4.0	Shale, olive-green to grayish, limy, finely interlaminated with blue- to green-gray silty shale.
9	5.0	Sandstone, green- to pinkish-gray, very fine grained, lime-cemented, with green glauconite grains giving the rock a greenish tinge. The sandstone is in thin lenticular layers that are parted by green shale, cross-laminated, and contains abundant molds and casts of various kinds; the usual varied worm(?) burrow casts typical of member B, and some that resemble small pelecypod(?) casts.
8	12.0	Shale, green-gray to gray, limy, very sandy, impure, and contains a few glauconite(?) grains.
7	1.0	Redbeds. Interlaminated claystone, siltstone, and very fine grained sandstone. All types are red-brown in color.
6	6.0	Sandstone, mottled reddish and greenish. The lighter parts are white to green-white, very fine to fine-grained lime-cemented sandstone containing green clay streaks. The greenish color in the sandstone is caused in part by green glauconite(?) grains. The bed contains white calcitic ooliths with clayey green glauconite centers. The reddish part of the interval is the weathered, or altered, or stained counterpart of the lighter colored portions. Of interest in the reddish part are the numerous red peppery silt-sized grains suggesting altered grains of glauconite or magnetite. The bed is soft, friable and forms a gentle covered slope.
	29.5	Total thickness of member B of the Sundance formation
	33.5	Total thickness of the Sundance

Contact of member B of the Sundance with the Nugget sandstone

5	5.5	Sandstone, white, weathers yellow-white to pink in places, very fine to fine-grained, with few dark impurities. The bed is soft, friable and forms a nearly flat-lying covered slope. The base of this sandstone is covered. This bed may be a part of the Canyon Springs sandstone.
4	80.0	Covered interval. Probably conceals red-brown sandstone. The covered interval makes a slope leading up to the ridge made by the upper member of the Jelm.
	85.0	Total thickness of the Nugget sandstone (possibly includes Canyon Springs sandstone at top)

Contact of the Nugget sandstone with the upper member of the Jelm formation

3	30.0	Sandstone, red-brown, mottled pink-gray, fine-grained above, coarse-grained and conglomeratic at the base. Thin zones of clay pebbles occur in the upper part. The conglomerate at the base contains siltstone pebbles in

Bed	Feet	Description
		addition to the common clay pebbles, and is believed to be the lithologic equivalent of the Jelm conglomerate of previous sections.
	30.0	Total thickness of the upper Jelm
Contact of the upper member with the lower member of the Jelm		
2	164.0	Sandstone, orange-white to orange-brown. The upper part contains thick red-brown shale beds mostly covered, the lower half is solid sandstone to the top of the Chugwater.
	164.0	Total thickness of the lower Jelm
	194.0	Total thickness of the Jelm
Contact of the Jelm with the Chugwater formation		
1	400.0+	Redbeds. The uppermost beds of the Chugwater formation, which are in contact with the Jelm formation, are composed of red-brown shale mottled green.
Base of examined section		

SECTION VIII: RED MOUNTAIN

Red Mountain is about 25 miles southwest of Laramie on the margin of the Laramie Basin. The section was measured near the head of a canyon whose east wall forms the west slope of a northward projecting spur on the north flank of Red Mountain (Pl. 4, A). The section is located in the SW 1/4 NW 1/4 Sec. 16, T. 12 N., R. 76 W. The spur is conspicuous and can be seen from 20 to 30 miles away owing to the bright purplish-red color of the nearly vertical walls of Chugwater at its base. The locality can be reached by walking about one mile eastward from Stop 15, p. 34, Guidebook of the First Annual Field Conference of the Wyoming Geological Association, 1946.

Morrison formation (in part)		
32	10.0+	Shale, green-gray, limy, with numerous thin beds of green-gray limestone and sandstone.
Contact of the Morrison with member A of the Sundance formation		
31	10.0	Sandstone, yellow-white, weathers yellow-buff, medium- to coarse-grained, cemented by medium-textured clear calcite crystals. Practically all the grains are subangular to well rounded. The well rounded grains are frosted and pitted. Numerous clear, orange, red, pink, yellow, and black chert and quartz grains were noted. Ooliths and weathered clayey green glauconite grains, indistinguishable from the nuclei of the white calcitic ooliths described from rocks of the previous sections, are present. Some of the ooliths are partly replaced by silica and are hollow-centered. In general, the lithologic features of this sandstone are quite similar to those of member A of the Jelm and Centennial sections. The sandstone is parted by ripple-marked surfaces into beds 1 to 8 inches thick. In places the parting surfaces are coated with a layer of oolitic blue-white chalcedony which in turn is coated by a thin layer of chalky calcite. The chalcedony-calcite layer is up to 1/4 inch thick, and, along with the sandstone surface on which it rests, is wrinkled in an intricate diminutive pattern. This "microfolded" structure is impressed upon and apparently secondary to the ripple marks. The chalcedony is in fresh contact with the sandstone and separates the latter from the chalky white calcite layer which appears to have partly replaced the chalcedony. One slab was observed which was subdivided into irregular polygons by a network of chalcedony septae normal to bedding. The sandstone segments of the slab were held together entirely by the chalcedony. This is interpreted as chalcedony fillings of pre-existing mud cracks in the sandstone. Mud crack fillings apparently are common features in the Summerville formation (Gilluly and Reeside, 1928). The sandstone locally is stained brown by organic matter. It weathers into a slabby vertical-faced ledge.
	10.0	Total thickness of member A
Contact of member A with member B of the Sundance		
30	5.5	Siltstone, dark-green, lime-cemented, platy, hard, porous, with minute glauconite grains as the only impurities observed. The siltstone is finely interbedded with blue-green limy shale, and forms a slope. Five feet below the top is a 1-inch layer of blue-white banded chalcedony with finger-like veinlets of white amorphous calcite. The layer contains a few glauconite grains.
29	10.0	Shale, greenish-brown to olive-drab, limy, platy, flaky, moderately hard with smooth conchoidal fractures. The upper 5 feet is thinly interbedded with finely cross-laminated glauconitic siltstone. One foot above the base of the shale is a 6-inch purple-red medium- to coarse-grained calcite-cemented sandstone, with many large rounded frosted quartz and chert grains. The shale underlying the 6-inch sandstone bed rests in turn on a conglomeratic sandstone ledge(Bed 28) which when followed southward along strike for about 15 feet is cut off by and incorporated into the shale in the form of large rounded boulders. A few feet farther the conglomeratic sandstone disappears entirely and the shale of this interval rests directly on Bed 27.
28	1.5	Sandstone, gray, weathers rusty-gray, medium-grained, lime-cemented, glauconitic(?), conglomeratic, with many coarse to very coarse subrounded polished quartz and chert grains. Angular white feldspar pebbles up to 1/4 inch in diameter are present with weathered pink-stained exteriors. Some large soft red grains are also present. Yellow chalky limy clay pebbles up to 2 inches in diameter are common. The rock has a "trashy" appearance. In addition, white calcitic pelecypod(?) shell fragments were observed. The conglomeratic sandstone is present as a ledge-former, can be seen as cobbles near the base of the overlying shale, and finally disappears in a horizontal distance of less than 30 feet. The cobbles are mostly ovoid in shape and are up to 9 inches in diameter. Some fragments are discoidal, 2 inches thick and 7 inches long. Of interest is the hardened thin upper surface of the ledge. This crust is purplish-black, impervious, and the grains of quartz cemented to it are worn down almost to the level of the matrix. The grains when separated from the matrix thus appear spheroidal, but beveled on one side. Only a small area of the hardened surface is exposed, but inasmuch as it may be found buried by the overlying shale, it seems certain that the surface is a fossil surface, at one time subject to wind action which abraded the exposed surfaces of the grains prior to the deposition of the overlying shale.
27	2.0	Sandstone, pink-white, fine- to medium-grained, lime-cemented, glauconitic(?), contains a few large subangular to well rounded frosted quartz and chert grains. Large soft shiny and clayey red grains are common. The bed

Bed	Feet	Description
		is massive and forms a reentrant.
	19.0	Total thickness of member B
	29.0	Total thickness of the Sundance
Contact of member B of the Sundance formation with the Nugget sandstone		
26	12.6	Sandstone, banded from top to bottom: salmon-pink, pink-red, white, and pink-white, fine-grained, limy, cross-laminated, with numerous medium rounded frosted quartz and chert grains concentrated along laminae traces and surfaces. Shiny red grains are common throughout. The sandstone forms a rounded shoulder. This interval may contain the Canyon Springs sandstone.
25	3.5	Sandstone, laminated in pink and white bands a few mm. thick, very fine grained, limy, soft, porous, friable. The bed has a varved appearance because of the fine alternating white and pink laminae. The traces of the laminae take on a ripply or minutely folded appearance in places as they are followed along strike. The white laminae contain clayey green glauconite(?) grains. The sandstone makes a vertical-faced ledge.
24	6.0	Sandstone, salmon-pink to white in places, fine- to medium-grained, noncalcareous, friable, contains sporadic coarse nearly spherical grains of clear quartz in the lower part. The white parts of the rock contain clayey green glauconite(?) grains. The rock is massive throughout, with faintly discernible cross-lamination near the top. In one place this unit was observed to cut into the underlying rock for a distance of one foot. The contact drops by one foot along a smooth S-curve and continues along a flat surface for a distance of 20 feet, where it is covered by a talus slope. This is interpreted to represent the filling of a shallow round-shouldered flat-bottomed channel in Bed 23 by Bed 24. The sandstone makes a rounded massive shoulder, identical to Bed 26.
23	2.5	Sandstone, orange-white to pink-white, identical in all other respects to Bed 25.
22	0.4	Conglomerate, reddish to pink-white. The matrix is a fine- to medium-grained, calcite-cemented sandstone composed of rounded frosted clear quartz grains. Larger coarse to very coarse white, orange, pink and gray quartz and chert grains are common. The conglomerate fragments consist primarily of white, orange, pink, purple, gray and black chert pebbles. A few clayey white feldspar pebbles are also present. The largest pebble observed was a white, sharply angular chert pebble 3/4 inch in length. This pebble had been broken into two halves which were separated by less than 1/4 inch, and the intervening space filled with sandstone. No signs of wear because of transport were noted on this pebble.
21	28.0	Sandstone, red-pink to orange-pink, mottled and banded green-mauve and lavender in the upper part, very fine grained, limy, silty, contains many clayey green grains similar to those forming the nuclei of the white calcitic ooliths described from rocks of previous sections. Numerous medium frosted pitted subrounded to very well rounded clear quartz grains are present. Some of the mineral grains (glauconite?) have altered and stained the enclosing rock bright red. The sandstone is thinly cross-bedded and weathers into lenticular slabs. The bed forms a vertical slightly reentrant surface at the base of the cliff formed by units 22 through 26. The lower part forms a partly covered slope.
	53.0	Total thickness of the Nugget sandstone (possibly includes Canyon Springs sandstone at top)
Contact of the Nugget sandstone with the upper member of the Jelm formation		
20	5.0	Sandstone, purplish to red-brown, very fine grained, limy, silty, profusely micaceous. The mica flakes form a definite layer on the surfaces of the laminae. The sandstone is green at the contact with the overlying bed, and has the appearance of a platy red-brown shale on the outcrop.
19	24.0	Sandstone, purplish-pink to purple-red, very fine grained, limy, impure. The sandstone is very thinly cross-bedded and presents a shingled appearance on exposed surfaces. The "shingles" are 1/4 to 1/2 inch thick. Two sets of joints are present that are normal to each other and approximately at a 45 degree angle to the strike. Parallel to the joints are zones of green-white bands up to 8 inches wide, which in places send finger-like extensions into the surrounding purplish rock. It would appear that solutions entering the rock along the fractures have leached out the pigment responsible for the color of the remainder of the rock. This bed grades down into the underlying one with no apparent lithologic break.
18	4.0	Sandstone, green-white, weathers gray, very fine grained above, medium-grained below, lime- and calcite-cemented. Red-brown and green clay pebbles along with conspicuous dark mineral flakes are abundant especially near the base. One of the red-brown clay pebbles has a green core. A few glauconite(?) grains are present. The sandstone forms a slightly overhanging slabby ledge, and in places channels into the underlying conglomerate.
17	1.0	Conglomerate, lavender to reddish-brown. The matrix consists of a conglomeratic mixture of limy fine- to very coarse grained sandstone, siltstone and clay. The larger quartz and chert grains are rounded, frosted and pitted. Dark mineral flakes are abundant. The fragments of the conglomerate consist of pebbles, cobbles and boulders of siltstone and sandstone. The largest fragments are of very limy sandstone and attain a maximum diameter of 1 foot. In addition, pebbles of lime- and silica-replaced wood fragments are present. All wood pebbles found were probably originally silica-replaced, while the limy wood fragments probably represent a secondary replacement of the silica. Two flat discoidal boulders were observed 2 inches thick and 1 foot in diameter, that were arranged in an overlapping manner dipping to the south as though the current of the water, by which they were transported and deposited, had flowed from north to south. The conglomerate channels into the underlying bed as much as 1 foot.
16	12.5	Sandstone, lavender-brown above, mottled green-white below, fine- to medium-grained, lime-cemented, "trashy" appearing because of the presence of abundant dark mineral flakes. Red-brown clay pebbles are common, often in a matrix of green-white sandstone. The lavender-brown upper part is banded green and yellow in places and forms a reentrant. The green-white mottled lower part forms a slabby ledge. The entire interval is cross-bedded.
15	1.0	Shale, red-brown, limy, silty, reentrant.
14	1.5	Sandstone, green-white, weathers rusty yellow-gray, fine-grained, lime-cemented, "trashy" appearing because of the presence of abundant dark mineral flakes. The bed forms a weak rounded ledge.
	49.0	Total thickness of the upper member of the Jelm

Bed	Feet	Description
		Contact of the upper member with the lower member of the Jelm
		Offset north to the extreme SW corner of Sec. 9, to the top of the spur (Pl. 4, A). The top of the spur is a surface cut on rocks at or near the top of the Jelm conglomerate (Bed 17).
13	16.0	Interbedded red-brown shale and green-gray siltstone. The interval forms a partly covered slope.
12	1.0	Siltstone, green-white, weathers gray, lime-cemented, micaceous, makes a hard ripple-marked crinkly ledge. The crinkled appearance is caused by imbricate ripple-structure.
11	8.0	Shale, red-brown, slightly limy, flaky, uniform, waxy.
10	1.0	Siltstone, green-white, weathers gray, lime-cemented, micaceous, hard, makes a slabby ledge.
9	4.0	Claystone, red-brown and blue-green, interlaminated, limy, sandy. The unit is predominantly red-brown above, blue-green below, and makes a reentrant.
8	4.5	Sandstone, reddish-pink with white spots, fine-grained, limy. The roughly circular white spots are caused by better cementation locally, and being more resistant to weathering stand up in minute wartlike protuberances. The sandstone makes a small rounded rough-textured ledge.
7	13.0	Sandstone, pink-white, weathers orange-pink, fine-grained, lime-cemented. The sandstone has white bands a few mm. thick, interlayered with sharply defined thin films of dark mineral grains. The basal 1 foot is white calcite-cemented unlaminated sandstone, with a very few green chlorite flakes the only impurities present. The bed makes a massive cross-laminated smoothly rounded shoulder.
6	9.0	Shale, chocolate-brown, noncalcareous, smooth, free of impurities, interbedded with red-pink and pink-stained very fine grained lime-cemented sandstone. Green chlorite flakes and green glauconite(?) grains are the only impurities observed in the sandstone.
5	3.0	Sandstone, greenish-white, very fine grained, lime-cemented, with very thin black laminae caused by films of black mineral grains. The bed contains green clay aggregates and pebbles 1/4 to 1/2 inch in diameter. The sandstone is in 3 beds, each 6 inches thick. A reentrant layer of red-brown noncalcareous waxy flaky shale separates the upper from the middle ledge, while a reentrant layer of red-pink very fine grained lime-cemented cross-laminated sandstone separates the middle from the lower ledge.
4	5.2	Sandstone, red-pink, very fine to medium-grained, lime-cemented. The larger grains are subrounded to well rounded, while the smaller ones are angular to subangular. The dark mineral grains form crude, poorly defined laminae, and in places form irregular aggregates. The sandstone is cross-laminated and forms a smoothly rounded massive ledge.
3	6.3	Sandstone, white, very fine grained, lime-cemented, stained pink on the outer surfaces, in beds 2 to 3 feet thick. Separating the ledge-forming sandstone are beds of dark reddish-brown slightly silty noncalcareous flaky shale. The reentrant shale in turn contains very thin lenticular cross-laminated white sandstone layers.
2	71.0	Sandstone, red-pink to red-orange, very fine to fine-grained, lime-cemented. The upper part is massive, cross-laminated and contains numerous large rounded polished quartz and chert grains especially abundant along laminae traces and surfaces, while the lower part is massive or thick-bedded. The interval forms a rounded ledgy cliff. The basal few feet are talus covered and the Jelm-Chugwater contact is concealed. The contact is obvious, however, inasmuch as the top of the Chugwater forms a wide flat-lying shelf from which the rounded Jelm cliff rises rather abruptly.
	142.0	Total thickness of the lower member of the Jelm
	191.0	Total thickness of the Jelm
		Contact of the lower member of the Jelm with the Chugwater formation
1	400.0 +	Claystone, red-brown with green-lavender zones, limy, slightly silty, micaceous, blocky, interbedded with red-brown sandstone, siltstone, and limestone-like ledges of green-gray hard siltstone. The Chugwater forms steep bare walls on the sides of the northward projecting spur on the north flank of Red Mountain.
		Base of measured section

SECTION IX: RING MOUNTAIN

The Ring Mountain section is an isolated small outcrop of fossiliferous limestone. It is of interest in that it is the southernmost locality in the Laramie Basin from which identifiable marine Jurassic fossils have been obtained.

The outcrop is in the form of a low ledge about 3 feet wide and 20 feet long. The overlying and underlying rocks are completely covered by grassy slopes and flats.

The nearest named geographic feature is Ring Mountain, some 2 1/2 miles southwest of the outcrop.

The dirt road passing through the SW corner of Sec. 28, T. 13 N., R. 76 W., was followed for 0.8 mile northeast from the section corner on a bearing of N 34 degrees E. At the end of that distance the road divides and passes on either side of an isolated outcrop of gray sandstone, probably of the upper member of the Jelm formation. About 100 feet up the slope from this outcrop, toward a ridge to the east capped by the basal Cloverly sandstone, will be found the Sundance outcrop that is the subject of this description. By the auto traverse, the locality should be in the SW 1/4 NW 1/4 NE 1/4 Sec. 28, T. 13 N., R. 76 W. Using the topographic and geologic sheets of the Laramie-Sherman quadrangles, U.S.G.S. Folio 173, a point between the road as shown inthe folio and the Cloverly ridge would fall in the SE 1/4 NE 1/4 of the same section, township and range.

		Sundance formation in part (Redwater shale member)
4	?	Covered interval.
3	1.0	Sandstone, gray-white, weathers brownish, medium- to coarse-grained, lime- and calcite-cemented. Has a

Bed	Feet	Description
		conglomeratic appearance at the base, becomes better sorted at the top. Large rounded frosted quartz and chert grains are present throughout. Angular to well rounded chert pebbles up to 1/4 inch in diameter are present. One yellowish clay pebble 3/4 inch long and 1/4 inch thick was observed. Green thin clay aggregates are common. Ooliths are numerous, some are replaced by silica, and of these some are hollow-centered. The reverse of the usual order was observed in one oolith whose outer shell was composed of white chalky calcite and whose center was made of brown calcite. Green clayey grains resembling green clayey glauconite nuclei of white calcitic ooliths are numerous. Fossil fragments are numerous but poorly preserved. Some of the fragments were thought to be those of Ostrea sp., Camptonectes bellistriatus(?), and Pentacrinus(?) sp.. The sandstone is covered by a thin grass-covered layer of alluvium. No fresh specimens were obtained.
3	1.5	Oolite-coquina, gray, cemented by coarse-textured calcite crystals, sandy near the top. Large rounded frosted quartz and chert grains are numerous throughout, especially so at the top. In places the bedding planes are weathered orange-brown. Pebbles were found in the oolite as follows: 1 gray smooth limestone pebble, 1 white clayey-surfaced feldspar pebble, 2 subrounded chert pebbles, one white and the other orange, 2 subrounded flesh-colored clay pebbles. The pebbles in general vary from 1/4 to 1/2 inch in diameter. Ooliths are abundant. The size of the ooliths varies from .25 to 1 mm. The ooliths have 1 to 4 concentric layers, with nuclei of green clayey glauconite, white calcite, and clear quartz grains. Most of the quartz-nuclei are rounded, some are sharply angular. Elongate ooliths are common. One 4-layered oolith with a quartz-grain nucleus was observed whose first and third layers were of white calcite, and whose second and fourth layers were of silica. Some of the siliceous ooliths are hollow-centered on weathered surfaces. The fractures of the rock are filled with white calcite. The oolite is in beds 3 to 5 inches thick and weathers with a rough pitted surface. The majority of the fossil fragments are Ostrea sp., the rest are Pentacrinus asteriscus and Meleagrinella curta. White water-worn(?) calcitic columnar objects are numerous. These may be Pentacrinus(?) fragments inasmuch on the sides may be seen the criss-cross cleavage pattern also found on definitely identifiable Pentacrinus stems. There is a possibility, however, that these may be echinoid spines.
1	?	Covered interval.
Base of measured section		

Note: Beds 3 and 2 of this section probably correlate with the basal oolitic beds of the Redwater shale member of the Sundance formation of the Como Bluff section. They probably pinch out westward, because they are not present in the Jelm section a few miles to the west, and pinch out or change facies southward, because they are not recognizable at the Red Mountain section, a few miles to the south, and definitely are absent in the Bull Mountain section. This would imply that at one time the Redwater shale was present in the south Laramie Basin area, and for an undetermined distance southward, but that a gentle uplift, at the close of Redwater time, of the area west and south of the Laramie Basin caused the Redwater shale to be stripped off prior to the deposition of member A of the Sundance formation. This disconformity easily inferred from a comparison of the sections shown on the correlation chart is evidenced in the northern group of measured sections only by an abrupt change in lithology between the Redwater shale and member A of the Sundance formation.

SECTION X: BULL MOUNTAIN, COLORADO

The Bull Mountain section was measured on the southwest flank of Bull Mountain, Colorado, about 4 1/2 miles south of the Wyoming-Colorado state line. The section was measured along a traverse about 100 feet north of and parallel to a barbed wire fence which lies along the southern boundary of the SE 1/4 SW 1/4 SW 1/4 Sec. 9, T. 11 N., R. 76 W. The southwest flank of Bull Mountain is the northeast limb of an anticline that plunges southeastward. The distance between the Bull Mountain section and the Red Mountain section is about 5 miles. The gate in the fence referred to has its east post braced with a large notched rock which marks the southwest corner of Section 9, T. 11 N., R. 76 W.

Morrison formation (in part)		
16	10.0	Shale, yellowish-green, limy, with numerous thin hard sandstone and limestone ledge-makers.
Contact of the Morrison with member A of the Sundance		
15	10.0	Sandstone, gray-white, weathers buff, rusty-orange in places, fine- to medium-grained, calcite- and lime-cemented. Near the base the matrix is coarsely crystalline clear calcite, whose cleavage faces give a sheen to the rock. Soft clayey green glauconite grains are present throughout, as are numerous coarse subangular to subrounded quartz and chert grains. A few very coarse frosted clear quartz grains seem perfectly spherical. The large rounded grains are clustered along laminae surfaces. In addition, lenticular green clay layers are found on the laminae surfaces. This thin- to cross-bedded slabby ripple-marked sandstone makes a ledge.
	10.0	Total thickness of member A
Contact of member A with member B of the Sundance		
14	5.0	Shale, blue-green to gray, very limy, silty, unusually gummy and sticky when wet, intergrades with siltstone. There are some lenticular thin hard calcite-cemented very fine grained sandstone and very sandy limestone layers near the middle. These thin layers contain glauconite and flesh-colored ooliths with green clayey glauconite centers. Some of the oolith nuclei have weathered to a red-orange color. The surfaces of the harder layers of the sandstone and limestone beds have the numerous worm(?) burrow casts, molds, etc., so common to this member.
13	3.0	Sandstone, white to greenish-white, weathers green-brown, very fine grained below, medium-grained above, lime- and calcite-cemented, parted by thin green shale layers. Poorly preserved ooliths, clayey green glauconite grains, and fossil fragments(?) are present. Some finely disseminated green grains seem to be weathering to a yellow color. The bed forms a slope.
12	4.0	Sandstone, white(?), weathers cream-yellow, very fine to medium-grained, lime-cemented, silty, contains clayey green glauconite grains and green glauconite(?) grains that are weathering yellow. The upper 1 foot is soft and forms a reentrant, the lower part is hard and forms a cross-laminated ledge.
11	4.0	Sandstone, white(?), weathers cream-yellow to pink-buff, very fine to medium-grained, limy, silty, contains mineral grains that have weathered yellow and numerous grains that have weathered red. The red grains give a spotted appearance to fractured surfaces. The sandstone contains 2 thin beds of bright blue-green noncalcareous shale, one near the top, the other in the middle. The sandstone is soft and forms a reentrant sandy slope.
	16.0	Total thickness of member B
	26.0	Total thickness of the Sundance

Bed	Feet	Description
		Contact of member B of the Sundance formation with the Nugget sandstone
		Members A and B of the Sundance formation are perfectly exposed in a gully about 400 feet south of the east-west fence. At this locality Beds 11 and 12 are missing and a 3-foot ledge of hard gray-green glauconitic sandstone (Bed 13) rests directly on the Nugget sandstone (Bed 10). Member A has thickened to 14 feet and is separated from Bed 13 by 5 feet of greenish shale and glauconitic sandstone (Bed 14). This loss of 8 feet of section can be explained by intraformational erosion or onlap. The author prefers the second explanation.
10	43.0	Sandstone, gray-yellow, salmon-pink in places, very fine grained, lime-cemented. This interval is practically identical to the Nugget sandstone of the Red Mountain section. It differs from the latter in that it contains no chert pebble horizons such as Bed 22 of the Red Mountain section, the pink, white-laminated beds are thinner (1 to 2 feet thick) and wedge out along strike. No channelling was observed within the Nugget sandstone of the Bull Mountain section. Except for the pink, white-laminated portions, the sandstone weathers into rounded bulging shoulders. The joints are zoned by a pink-lavender color while the main body of the rock is gray except for a salmon-pink zone at the top.
	43.0	Total thickness of the Nugget sandstone (possibly includes Canyon Springs sandstone at top)
		Contact of the Nugget sandstone with the upper member of the Jelm formation
9	4.0	Sandstone, green-white, weathers gray-brown, medium-grained, clayey, silty, cross-bedded, contains a conglomerate at the base similar to the Jelm conglomerate of the previous sections. No fragments of fossil wood or bone were observed at this locality. Coarse to very coarse subrounded and well rounded frosted pitted quartz and chert grains are numerous. Pebbles of yellow-gray siltstone, claystone, and green claystone are present throughout, but are concentrated near the base. At the base, subangular gray chert pebbles are common. The sandstone makes a slabby ledge and channels into the underlying bed.
8	36.0	Sandstone, contains a 6-inch layer of bright green noncalcareous uniform flaky shale at the top. The shale is red-brown in places. The sandstone is green-white, weathers orange-white below, lavender, maroon and purple above, medium-grained, lime-cemented, impure, "trashy" appearing, and contains micaceous clay near the top. The upper part is thinly cross-bedded and forms a sandy slope, covered except for harder white sandstone layers which outcrop as small ledges. The basal 10 feet is harder, green-gray, cross-bedded, contains clay pebbles near the base, and makes a ledge.
	40.0	Total thickness of the upper member of the Jelm
		Contact of the upper member with the lower member of the Jelm
7	19.5	Shale, red-brown, noncalcareous, platy, with numerous white very fine grained lime-cemented sandstone ledges up to 8 inches thick. The shale forms a slope, covered except for the white sandstone ledges.
6	10.0	Sandstone, contains a 3-inch red-brown, noncalcareous claystone bed 9 inches above the base. The sandstone is reddish-pink, weathers orange-red, very fine grained, lime-cemented, cross-laminated, with a few dark mineral grains present, contains red-brown clay pebbles just above the claystone parting near the base. The sandstone forms a prominent overhanging ledge.
5	16.5	Shale, very dark red-brown, sandy noncalcareous, with a few orange-red fine-grained limy sandstone ledges up to 1 foot thick. The interval is covered except for the ledges and a few feet beneath the contact with the overlying bed. Where the shale is well exposed near the top, it is slightly purplish and mottled green in places.
4	87.0	Sandstone, red-brown to red-pink, weathers orange-red, very fine to fine-grained, lime-cemented, contains dark mineral grains in aggregates and along laminae. The sandstone is massive, cross-laminated, forms a series of small ledgy rounded cliffs, and channels into the underlying bed.
3	4.0	Sandstone, reddish-purple, differs from the overlying bed in that it is darker colored, slightly coarser grained, less well cemented, and makes a slabby ledge.
2	1.0	Sandstone, pink-white, very fine grained, lime-cemented, hard, ripple-marked, finely laminated. This bed rests disconformably on the Chugwater formation. Within an exposure of the contact 15 feet in length, two small, relatively deep channels were observed in the upper part of the Chugwater formation, the largest of which is shown in Pl. 4, B. The channels average 2 feet in depth and 2 feet in width at the top, and contain hard rounded siltstone boulders up to 1 foot in diameter, which are cemented by the sandstone of Bed 2. The boulders are composed of gray to pink-white calcite-cemented siltstone which contains a few small green and brown clay pebbles and aggregates. On the whole the lithology of the boulders is quite similar to that of the matrix.
	135.0	Total thickness of the lower member of the Jelm
	175.0	Total thickness of the Jelm
		Contact of the lower member of the Jelm formation with the Chugwater formation
1	10.0 +	Siltstone, dark and light red-brown, limy, clayey, interbedded with uniform limy red-brown shale and claystone which contains "green eyes".
		Base of measured section

SECTION XI: DUTTON CREEK

The Dutton Creek section is adapted from lithologic descriptions and thicknesses determined by H. D. Thomas on the basis of cores. The well (Union Oil Co.) is located in the NE SW SE Sec. 1, T. 18 N., R. 78 W., and has a surface elevation of 7,546 feet. The tops picked by Thomas are as follows. Morrison formation: 4,995; Sundance formation: 5,274; Sundance "orange sandstone": 5,334; Jelm formation: 5,440. The well bottomed in the Jelm at 5,468.

A comparison of this section with the Como Bluff section (see correlation chart) shows excellent agreement with respect to placement of major contacts, and in addition, the author believes that some of the minor subdivisions present at Como Bluff also can be differentiated in the Dutton Creek section.

Bed	Feet	Description	
Morrison formation (in part)			
30	2.3	Shale, greenish-gray, slightly limy, solid.	(5,260)
29	2.5	Limestone, dark-gray, grades down into gray arenaceous hard limestone.	
28	2.2	Shale, variegated green and red above, gray below, medium-hard, solid.	
27	1.2	Sandstone, gray, very fine grained, limy, with gray shale streaks.	
26	1.8	Shale, gray solid.	
25	0.9	Shale, gray, fine-grained, very hard, with shale streaks.	
24	0.7	Shale, dark-gray, medium-hard, brittle, solid.	
23	0.4	Intraformational breccia--gray limestone pebbles in a fine-grained gray sandstone matrix.	
22	1.0	Limestone, gray, hard, dense, slightly pyritiferous.	
21	1.0	Sandstone, gray, fine-grained, very hard, with small blue-green and black clay pebbles.	
	14.0	Partial thickness of the Morrison formation (Total thickness: 279 feet)	
Contact of the Morrison with member A of the Sundance formation			(5,274)
20	9.0	Sandstone, gray, fine-grained, limy with dark-gray shale partings near the middle. Much pyrite is present at the base.	
	9.0	Total thickness of member A	
Contact of member A with the Redwater shale member of the Sundance			(5,283)
19	5.0	Shale, black to dark-gray, solid, with numerous 1/4-inch laminae of green-gray fine-grained hard cross-laminated sandstone. Much pyrite is present throughout. The basal 1/2 foot is a sandstone similar to that of the laminae.	
18	6.0	Shale, dark-gray, medium-hard, with streaks of sandy shale and very fine grained dark-gray sandstone in the middle. The upper 3 feet and the basal 1 foot are sandy and fossiliferous. The lower 1 foot contains broken shell fragments.	
17	3.5	Shale, dark-gray, medium-hard, solid, with streaks of light-gray very fine grained hard sandstone.	
16	14.5	Shale, dark-gray, very sandy, medium-hard, contains Pachyteuthis "densus" throughout the lower 9 feet.	
15	0.7	Sandstone, dark-gray, medium-grained, hard.	
	29.7	Total thickness of the Redwater shale	
Contact of the Redwater shale with member B of the Sundance			(5,312.7)
14	3.1	Shale, dark-gray, very sandy, medium-hard.	
13	12.7	Sandstone, light-gray, fine-grained, very hard, contains streaks of greenish-gray solid shale in the upper 2 feet, and several paper-thin argillaceous streaks in the lower part.	
12	5.5	Shale, greenish-gray to gray, solid to solid-sandy, with streaks of gray very fine grained hard to very hard sandstone.	
11	12.0	Redbeds. Sandstone, red-brown, very fine grained, clayey, hard, irregularly bedded, with streaks of red-brown and green clay. The redbeds grade down into:	
10	3.0	Sandstone, light-gray or white, very fine grained.	
	36.3	Total thickness of member B	
Contact of member B with the Lak(?) member of the Sundance			(5,349)
9	5.0	Sandstone, gray, very fine grained, with a red-brown streak 1 1/2 inches below the top. The bed grades down into a fine- to medium-grained sandstone.	
8	6.5	Sandstone, light-gray, fine- to medium-grained, soft to medium-hard, with dark laminae showing cross-bedding.	
	11.5	Total thickness of the Lak(?) member	
	86.5	Total thickness of the Sundance	
Contact of the Lak(?) member of the Sundance formation with the Nugget sandstone			(5,360.5)
7	25.4	Sandstone, pink and white, very fine to medium-grained, very soft.	
6	21.4	Sandstone, salmon-red, fine- to medium-grained, very soft to soft, cross-bedded.	
5	30.8	Sandstone, varies from pink to white, fine- to medium-grained, soft to medium-hard.	
	77.6	Total thickness of the Nugget sandstone (may include Canyon Springs sandstone in upper part)	

Bed	Feet	Description
Contact of the Nugget sandstone with the upper member of the Jelm formation		(5, 438.1)
4	13.9	Sandstone, similar to the above, but with a few scattered maroon clay pebbles, about 1/4 inch in diameter. The base includes a 2-inch sedimentary breccia composed of angular maroon clay pebbles 1/4 inch to 2 inches in diameter.
3	3.6	Sandstone, gray, fine- to medium-grained, hard. The lower 2 feet is a clay pebble conglomerate similar to that in the overlying bed.
2	5.9	Sandstone, buff to pink, fine-grained, soft, finely laminated. The lower 1 1/2 feet is a clay pebble conglomerate containing fragments of fossil bone.
1	4.5	Sandstone, fine- to medium-grained at the top, grading down to medium-grained "dirty" gray sandstone. The basal 2 inches is medium- to coarse-grained.
	27.9	Approximate thickness of the upper member of the Jelm. Bottom of the well. Judging from the lithology, the bottom of the well is within a very few feet of the top of the lower member of the Jelm formation. (5, 466)

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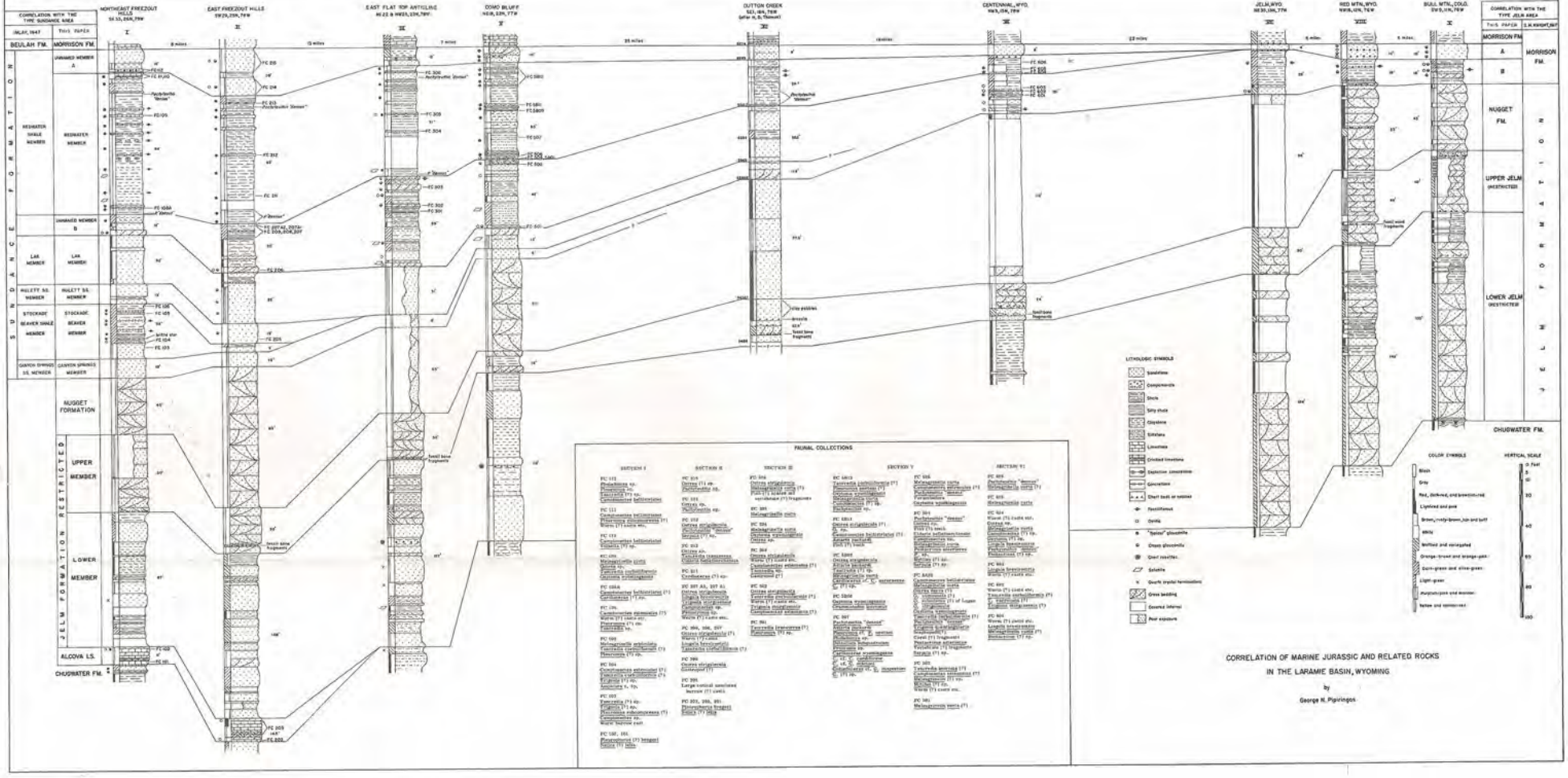

CORRELATION OF MARINE JURASSIC AND RELATED ROCKS
IN THE LARAMIE BASIN, WYOMING

by

George N. Pipiringos