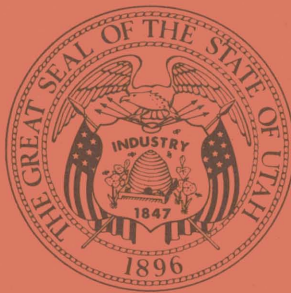


Stratigraphy of the Duchesne River Formation  
(Eocene-Oligocene?), Northern Uinta Basin,  
Northeastern Utah

*by David W. Andersen and M. Dane Picard*

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY  
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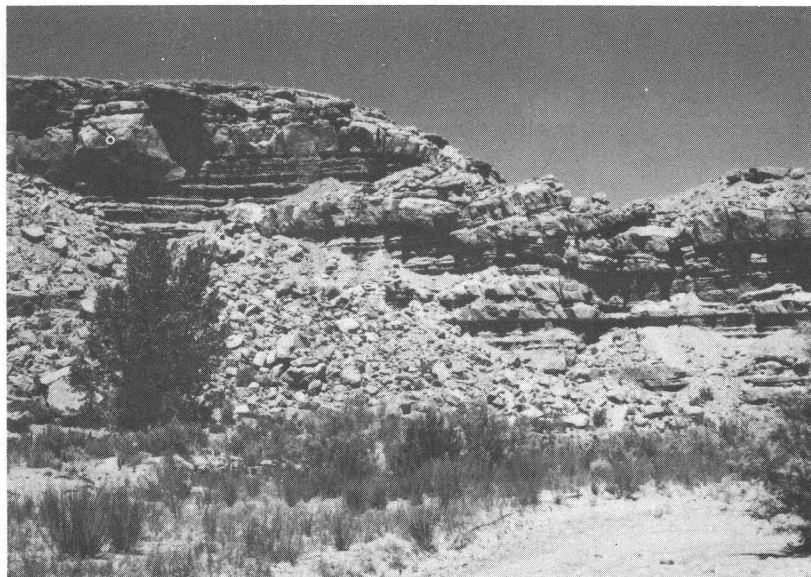
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# Stratigraphy of the Duchesne River Formation (Eocene-Oligocene?), Northern Uinta Basin, Northeastern Utah

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Laterally discontinuous sandstone lenses interbedded with fine-grained rocks in Brennan Basin Member near Twelvemile Wash (see figure 12).

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# STRATIGRAPHY OF THE DUCHESNE RIVER FORMATION (EOCENE-OLIGOCENE?), NORTHERN UINTA BASIN, NORTHEASTERN UTAH

by David W. Andersen<sup>1</sup> and M. Dane Picard<sup>2</sup>

## ABSTRACT

The Duchesne River Formation consists of more than 3,000 feet of fluvial conglomerate, sandstone and fine-grained rocks. It is important in North American continental stratigraphy because it is the standard section of the latest Eocene Duchesnean Stage. Study of the Duchesne River Formation has been limited, however, by the lack of suitable stratigraphic subdivisions within the formation.

Revision of previous informal nomenclature is proposed. The Duchesne River Formation is here subdivided into four lithostratigraphic units (from oldest to youngest): the Brennan Basin, Dry Gulch Creek, Lapoint and Starr Flat members. The Brennan Basin and Dry Gulch Creek members represent a revised subdivision of the Randlett and Halfway horizons of former usage. The Lapoint Member is essentially equivalent to the previously described Lapoint horizon. The Starr Flat Member consists of beds, most of which have not been described previously.

The Brennan Basin Member is characterized by discontinuous lenses of cross-stratified sandstone interbedded with reddish brown fine-grained rocks. Coarse conglomerate is abundant in this member on Asphalt Ridge. The Dry Gulch Creek Member consists mainly of reddish brown and greenish gray fine-grained rocks and interbedded thick, persistent sandstone layers. The Lapoint Member is composed of light greenish gray bentonitic claystone and minor reddish brown conglomerate, sandstone and fine-grained rocks. The Starr Flat Member is characterized by reddish brown conglomeratic sandstone and lesser amounts of fine-grained rocks.

The rock units are partly lateral equivalents whose times of formation overlap somewhat. The members, however, are recognizable lithostratigraphic units that are traceable throughout the outcrop area of the formation. The new members thus represent an improvement over the earlier informal terminology. Their adoption will facilitate paleontological exploration and provide a framework for understanding the depositional history of the Duchesne River Formation.

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## INTRODUCTION

The Duchesne River Formation is a well exposed, extremely variable sequence of clastic sedimentary rocks more than 3,000 feet thick in the northern Uinta Basin of northeastern Utah. The Uinta Basin is an area of economic importance and the thick fluvial-lacustrine sequence provides an outstanding record of Eocene deposition. Detritus in the Duchesne River Formation was derived primarily from the ancestral Uinta Mountains, a source area composed almost entirely of sedimentary and low-grade metamorphic rocks. Because of the simple relationship with the source area, most of which is still available for comparison, the formation provides a standard by which the representation of certain kinds of source material in sedimentary deposits can be evaluated. The formation also provides an excellent opportunity for the study of several aspects of fluvial sedimentology. In contrast to other Eocene deposits of the Uinta Basin, study of the Duchesne River Formation has been complicated by the lack of suitable designated stratigraphic units. Detailed study of the formation has revealed the existence of traceable lithostratigraphic units that form a framework within which the depositional history of the formation can be understood.

Nearly all of the Duchesne River Formation consists of clastic sedimentary rocks. Rock types range from coarse conglomerate to claystone, with a complete gradation of intermediate sizes. Sandstone is most abundant, comprising about 50 percent of the formation. Conglomerate and fine-grained rocks are less abundant and constitute about 10 and 40 percent, respectively.

## PREVIOUS STUDIES

### Early Work

The first geologic map of the Uinta Basin was published by Clarence King in 1878. At that time, little was known of the "Tertiaries" south of the Uinta Mountains and they were mapped collectively as the "Uinta Group." Interest in these deposits continues, largely because of the work of vertebrate paleontologists.

Following the early reconnaissance of Marsh (1871), several paleontologists studied the Uinta Basin

in detail. The results of some of these studies were described by Osborn (1895). Osborn also quoted the notes of O. A. Peterson, who suggested that the richly fossiliferous section of the "Uinta Group," including most of the strata overlying the "Green River Shales," should be faunally subdivided from the base upward into the A, B and C horizons. Later, Douglass (1914) suggested that the "Uinta Group" of King be referred to as the "Uinta Tertiary" to avoid confusion with the Precambrian material in the Uinta Mountains.

#### Age of Duchesne River Formation

The redbeds of the "Upper Uinta" were separated from the underlying "Uinta Tertiary" by Peterson and Kay (1931) on the basis of a new vertebrate fauna (described in part by Peterson in 1931), which was then believed to be earliest Oligocene in age. Some difficulty was noted in locating a traceable lithologic boundary, but the base of the resistant brown sandstones north of Randlett, Utah, was selected. Scott (1932) and Peterson (1932) recognized that the name "Upper Uinta" was a source of possible confusion and both proposed that the new name "Duchesne" be applied to the "Oligocene horizon" overlying the Uinta Formation (Peterson, 1932, p. 61). In addition, Peterson noted that the Duchesnean fauna appeared less distinct from the Uintan than previously supposed. He considered it transitional between the faunas of the Uintan (uppermost Eocene) and Chadronian (lowermost Oligocene) stages, but continued to assign it an Oligocene age.

In his correlation of Tertiary formations, Simpson (1933) also noted the transitional nature of the Duchesnean fauna. Since the Duchesnean horse, *Epihippus (Duchesnehippus) intermedius*, seems to be more closely related to the Eocene *Ehippus* of the Uinta than to the Oligocene *Mesohippus* of the Chadron, Simpson included the "Duchesne" in the late Eocene. Kay (1934) noted that the name "Duchesne" is preempted in North American nomenclature and proposed the new name Duchesne River for the formation, which he also further divided into three horizons. Supported by descriptions of new fossil material by Burke (1934b) and Peterson (1934), Kay returned the Duchesne River Formation to the Oligocene Series. In a subsequent correlation of the North American continental Tertiary, Wood and others (1941) followed the suggestions of Simpson. They formally established the Duchesnean Age, typified by the titanotheres *Teleodus*, as the youngest subdivision of the Eocene Epoch.

Scott (1945) later published a comprehensive systematic review of the Duchesnean fauna. Although Scott emphasized the transitional nature of the assemblage, he concluded that its affinities with the Chadronian fauna justified assignment of the formation to the Oligocene Series.

In Scott's opinion, the sudden and almost complete change in the fauna from the Uinta to the Duchesne River Formation suggested a considerable hiatus at their contact.

Simpson reviewed the debate and noted that the placing of the Eocene-Oligocene boundary in such a gradational sequence is largely arbitrary and is a matter of convenience rather than of right and wrong (Simpson, 1946, p. 53). Several factors were considered by Simpson: the Duchesnean fauna has more families and genera in common with the Uintan than with the Chadronian, the species are probably more closely related to the earlier age, the great incursion of newcomers was between the Duchesnean and Chadronian, the striking change in deposition took place after the Duchesnean, and the semiofficial correlation of Wood and others (1941) included the Duchesnean in the Eocene. For these reasons Simpson concluded that it would be more convenient to include the Duchesnean Age in the Eocene Epoch.

Simpson's opinion generally has been accepted in subsequent work (Wood, 1949, 1955, 1956 and 1962; Gazin, 1955 and 1959; Kay, 1957; Stokes and Madsen, 1961; Evernden and others, 1964; Dawson, 1966; Romer, 1966; Kummel, 1970). Some variation in usage has persisted, however. Kinney and Rominger (1947), Kinney (1955) and Warner (1963 and 1965) considered the formation Eocene and possibly Oligocene in age. Huddle and McCann (1947) and Untermann and Untermann (1964) listed its age unequivocally as Oligocene. Some workers probably continue to assign an Oligocene age to the formation because that age appears frequently in earlier literature, and such an assignment for part of the formation may be partly justified. The rather thick fluvial sequence contains numerous diastems and minor erosional breaks and the formation may represent a greater duration of time than previously suspected. Although the lower parts of the Duchesne River Formation are probably latest Eocene in age, the uppermost parts are undated and could be much younger. Furthermore, fossil remains are still relatively few and additional material will be found. At present, an assignment of Eocene and possibly Oligocene age is justified.

Whether or not the Duchesnean Stage is ultimately left in the Eocene or returned to the Oligocene, its absolute age is of considerable interest. Three potassium-argon dates of about 37.5 million years (my) for the Norwood Tuff in Utah have been assigned to the Duchesnean (Evernden and others, 1964, p. 165), although more recent work suggests that most of the Norwood Tuff is Chadronian in age (Nelson, 1971). Datable volcanic materials are present in the Duchesne River Formation in the Uinta Basin; a date of 39.3 my

was obtained by John Clark from an ashy siltstone at the contact of the Dry Gulch Creek and Lapoint members (M. R. Dawson, 1972, personal communication). Further dates are needed and can be obtained.

#### Stratigraphic Studies

Probably because of few economic incentives, the Duchesne River Formation has received less attention than other Tertiary deposits in the Uinta Basin. Incidental attention to Tertiary strata was given on maps published by Huddle and McCann (1947), Kinney and Rominger (1947), Huddle, Mapel and McCann (1951) and Kinney (1955). These maps indicate areas of Tertiary rocks, but no distinction is made between the Duchesne River and Uinta formations. Small-scale maps compiled by Untermann and Untermann (1964) and by Stokes and Madsen (1961) indicate outcrop areas of the Uinta and Duchesne River formations, but detailed discussions of contacts and stratigraphic relationships are not included. Partly because a detailed map of the entire extent of the Duchesne River Formation is unavailable, relationships between the Duchesne River and underlying formations are inadequately known.

In the variable fluvial and lacustrine deposits of the Uinta Basin, complex intertonguing relationships and facies changes are common. The coincidence of abrupt faunal changes with conspicuous lithologic boundaries that was eagerly sought by the early workers thus seems unlikely.

Two previous attempts were made to describe the stratigraphic intervals within the Duchesne River Formation. Kay (1934) divided the formation into three rock units: the Randlett, Halfway and Lapoint "horizons." These units are used by vertebrate paleontologists for cataloguing fossils collected near the type sections. Because these horizons have not been confidently identified far from their type sections, Warner (1963) proposed different subdivisions. He divided the formation into a lower minor bentonite member and an upper major bentonite member. Both members also constitute a western sandy facies and an eastern muddy facies. The units are recognizable over large areas, but they are unnecessarily broad subdivisions. In addition, Warner's members were not proposed formally in accordance with the recommendations of the American Commission on Stratigraphic Nomenclature (1961), and they do not take into account the previous and continuing work of paleontologists who use the terminology of Kay.

The success of previous stratigraphic studies in the Duchesne River Formation was limited by several factors. (1) The typical contact of the formation with underlying units cannot be confidently traced far from

Randlett, Utah. (2) The upper parts of the formation are extensively eroded, leaving the youngest beds exposed in only a few localities. Previously measured "complete" sections do not therefore include much of the upper part of the formation. (3) The complex facies relationships between lithologic units were not adequately considered and (4) the primary interests of previous workers did not include the establishment of detailed stratigraphic correlations over large areas within the Duchesne River Formation. For these reasons, the formation as a whole has not been adequately subdivided into stratigraphic units that are recognizable throughout the outcrop area.

#### TERMINOLOGY

The terminology used here is from many sources. Color terms are those defined by Goddard and others (1948). Terms for splitting properties, bedding thickness and stratification types are primarily those of McKee and Weir (1953). Four additions were necessary. Rocks showing spheroidal weathering are termed nodular. Friable rocks are too crumbly to split at all. Thick strata without apparent internal layering are termed structureless after McCormick and Picard (1969). The term lenticular stratification is used to describe structureless lenticular strata with less than 30 feet of lateral extent.

Most clastic rocks are named according to the median grain size of the framework constituents. Following the usage of Pettijohn (1957), a rock is termed conglomerate if it is composed of more than 30 percent material larger than 2 mm. Pebbly sandstone contains 5 to 30 percent material larger than 2 mm. Terminology for sandstones and fine-grained rocks is from Wentworth (1922) and Picard (1971). In sandstone, more than 50 percent of the detrital fraction is material in the range from 1/16 to 2 mm. Fine-grained rocks are termed siltstone or claystone if more than 50 percent of the detrital fraction is silt or clay, respectively. In mudstone, no size class comprises more than 50 percent of the rock. Useful modifiers are sandy, silty and clayey.

Compositional terms are modified from the sandstone classification of Folk (1968). Descriptive terms are applied to clastic rocks of all grain sizes, so the suffix -arenite is replaced by adjectival endings. Quartzose, sublithic and lithic groups thus correspond in composition to quartzarenite, sublitharenite and litharenite, respectively, but apply to conglomerates and fine-grained rocks as well as to sandstones. Note that a lithic composition has no relationship with the processes of lithification and induration. Sorting is described as good (1 to 3 grain size classes), moderate (4 to 6 classes) or poor (more than 6 classes) after McCormick and Picard (1969, p. 1495). Conglomerates


Kay, 1934	Warner, 1963	This Paper
(not studied)	(not studied)	Starr Flat Member
Lapoint horizon	Major bentonite member	Lapoint Member
Halfway horizon	Minor bentonite member	Dry Gulch Creek Member
Randlett horizon		Brennan Basin Member
		 Conglomeratic facies

Figure 1. Correlation chart showing history of nomenclature for subdivisions of Duchesne River Formation.

are open, with a unimodal grain size distribution, or closed, with a bimodal distribution. Closed types can be intact (primary mode in gravel fraction) or disrupted (primary mode in finer sizes; Pettijohn, 1957, p. 254).

GENERAL STRATIGRAPHY

On the basis of lithology, splitting characteristics and bedding types, the Duchesne River Formation is subdivided into four lithologic units (from oldest to youngest): the Brennan Basin, Dry Gulch Creek, Lapoint and Starr Flat members. The Lapoint Member is equivalent to most of the Lapoint horizon of Kay (1934). The Brennan Basin and Dry Gulch Creek members represent a revised division of the strata included in the Randlett and Halfway horizons. The Starr Flat Member consists of beds, most of which have not been described previously. Figure 1 illustrates the relationship of the proposed subdivisions to previous terminology. The boundaries of the members are largely time-

transgressive and the units are therefore partly lateral equivalents, but their characteristics represent the interaction of source material and depositional environments and form distinct lithologic units with recognizable properties. Furthermore, these rock units include the entire formation as presently defined and they can be identified over large areas.

Eight stratigraphic sections were measured and sampled to establish the characteristics and distributions of the units, and type sections were selected from these. The locations of the sections are shown in figure 2. Of these sections, three include most of the thickness of the formation and are therefore complete sections. Five shorter sections were measured in locations that represent only a part of the formation, but which allow more confident correlation of individual beds and serve to illustrate lateral variations within the units. The longer sections were measured generally from south to north. The members strike generally east-west and the younger units lie to the north of older units, but it is beyond the scope of this study to present a detailed map of the distribution of the members.

Three stratigraphic cross sections (figures 3, 4 and 5) were constructed on the basis of the measured sections. They illustrate the characteristics of the members, indicate their boundaries and show the lateral and vertical relationships established among them. Heavy correlation lines on the cross sections indicate member boundaries and are not necessarily time planes. Lighter correlation lines indicate beds and inferred (dashed) correlation of individual beds or erosion surfaces. Numbered correlation lines (Roman numerals) appear on more than one cross section and the same

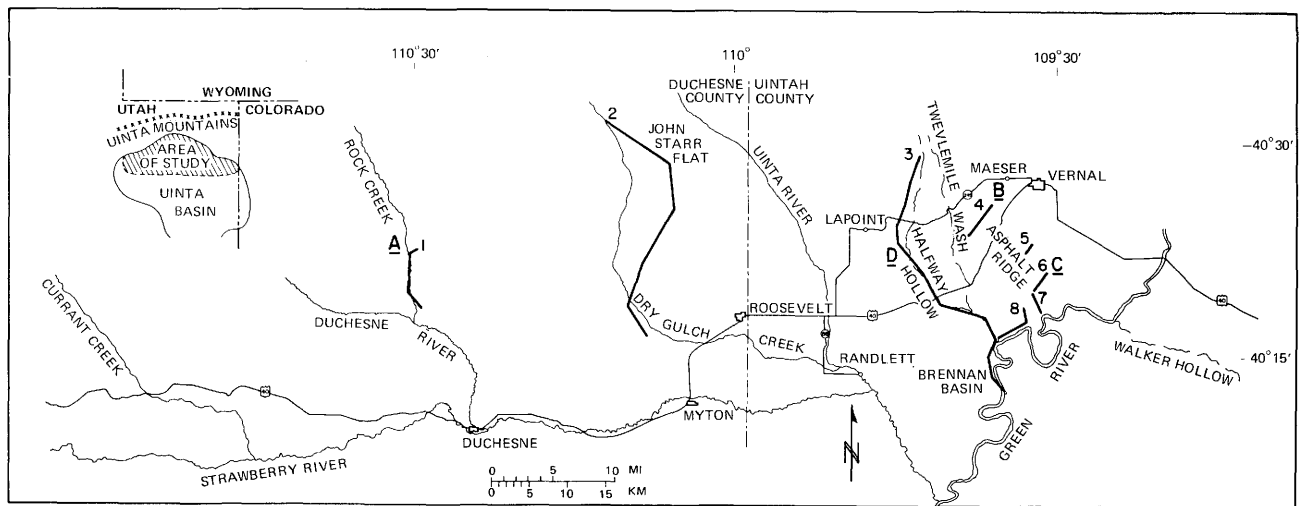


Figure 2. Index map of northern Uinta Basin, Utah. Measured sections are numbered (1-8). End-points of cross sections (figures 3, 4 and 5) are shown with large letters.

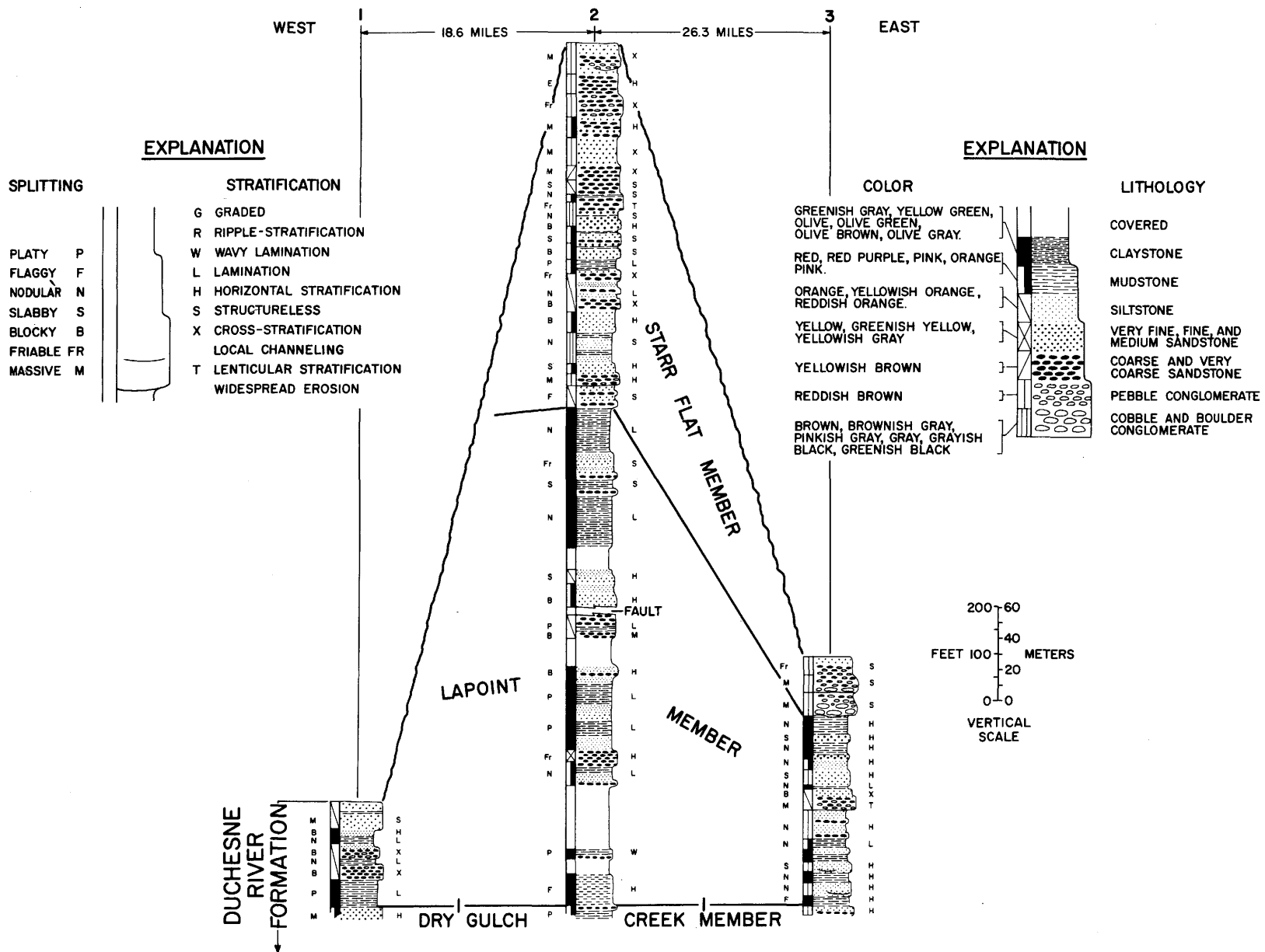


Figure 3a. West-east cross section of upper half of Duchesne River Formation from Rock Creek to Halfway Hollow. Terminology is discussed in the text.



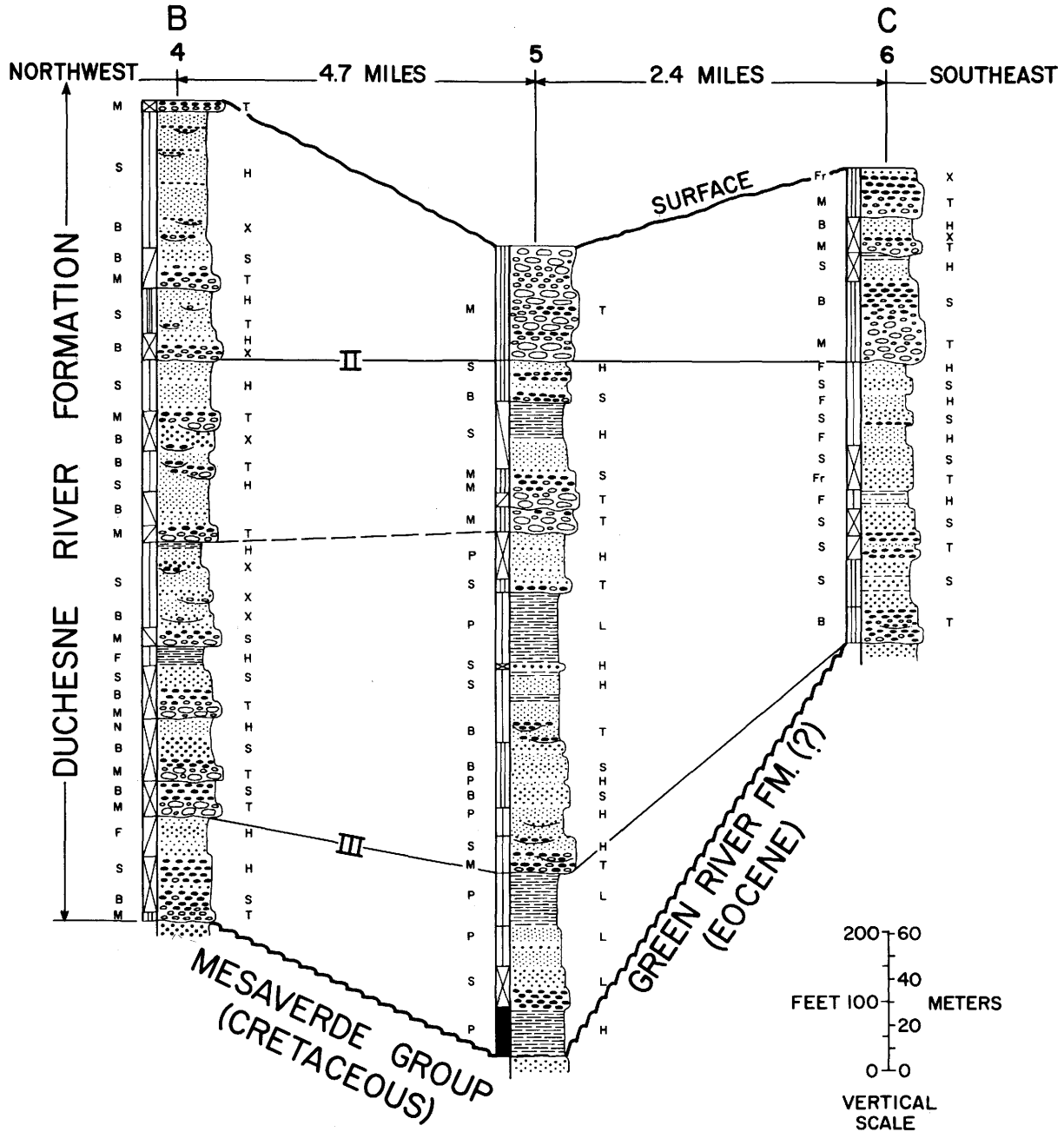


Figure 4. Northwest-southeast cross section of Brennan Basin Member along Asphalt Ridge. Legend same as figure 3a.

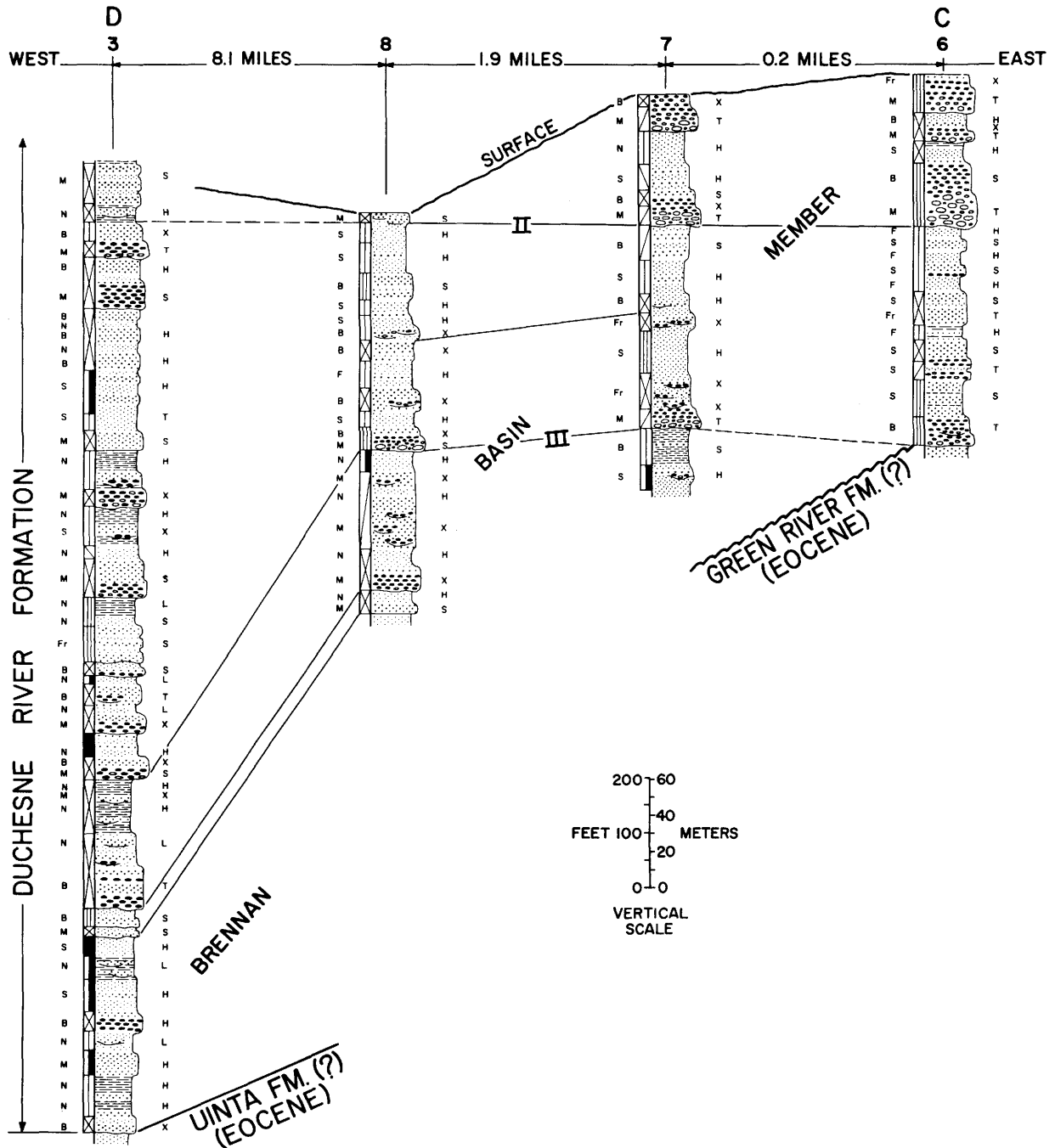


Figure 5. West-east cross section of Brennan Basin Member from Halfway Hollow to Asphalt Ridge. Legend same as figure 3a.

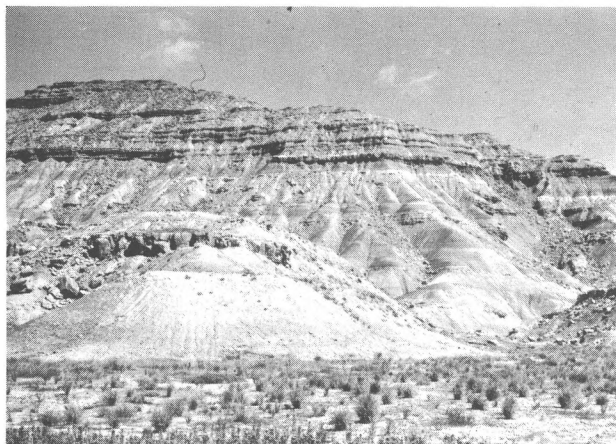


Figure 6. Reddish brown sandstone of Duchesne River Formation overlying variegated claystone of Uinta Formation, 3 miles east of Randlett, Utah.

number is given to a particular line in all sections on which it appears.

#### BASE OF FORMATION

The base of the Duchesne River Formation was first defined by Peterson and Kay (1931) at Randlett, Utah, where the resistant, reddish brown sandstone of the formation overlies variegated fine-grained rocks of the Uinta Formation (figures 6 and 7). In general, the Duchesne River Formation contains more abundant sandstone, is more conspicuously cross-stratified, and is redder in color than the underlying Uinta Formation (Peterson and Kay, 1931, p. 295). The contact maintains the same general appearance for approximately 30 miles to the west where the distinction becomes obscure and the Uinta Formation is sandy and locally red in color (figure 8).

Rapid changes in thickness of the Brennan Basin Member and tentative correlation of prominent sand-



Figure 8. Reddish brown sandstone of Duchesne River Formation overlying light colored sandstone of Uinta Formation near Duchesne, Utah.

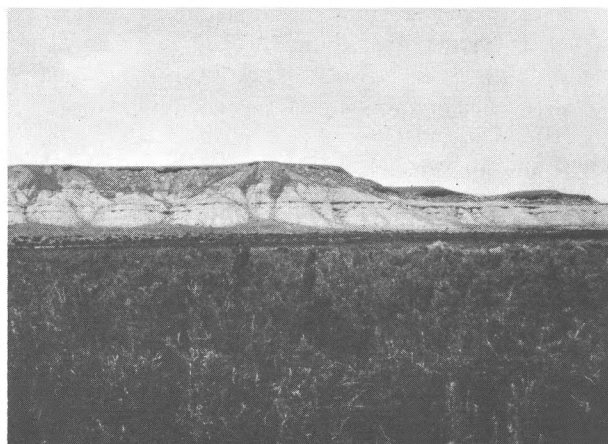


Figure 7. Duchesne River Formation overlying Uinta Formation, 7 miles northeast of Myton, Utah.

stone horizons (figure 3b, datum III) suggest that the boundary as mapped near the Green River and farther east is as much as 642 feet (196 m) below the boundary established at Randlett. Furthermore, additional "Duchesne River-like" tongues are present as much as 422 feet (129 m) below the mapped base of the Duchesne River Formation east of the Green River (figure 9). Reddish brown, sublithic and lithic sandstone, typical of the Duchesne River Formation, is mixed and interbedded with the lighter colored subarkosic and sublithic sandstone and fine-grained rocks of the Uinta Formation, probably representing a mixing of material from source areas on the north and on the east. Thus, it is suggested that the Uinta and Duchesne River formations intertongue through an interval of at least 1,064 feet (325 m). The boundary is placed at the top of the highest grayish red purple (5RP4/2) claystone of the Uinta Formation and the resulting position conforms with that shown by Untermann and Untermann (1964).

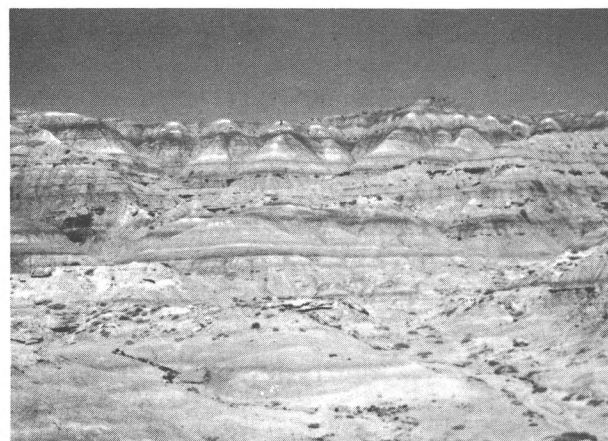


Figure 9. Reddish brown and brown tongues of Duchesne River-like sandstone interbedded with variegated claystone of Uinta Formation in Red Wash, 27 miles southeast of Vernal, Utah.

North and northeast of Randlett, Utah, the base of the Duchesne River Formation is an erosional unconformity, usually of low relief, but locally typified by high relief or pronounced angular discordance (figure 10). This unconformity is present along Asphalt Ridge and at several localities along the south flank of the Uinta Mountains where the Duchesne River Formation rests on units as old as the Upper Precambrian Mutual Formation.

## BRENNAN BASIN MEMBER

### Name and Type Section

The basal unit of the Duchesne River Formation in most of the area of outcrop is a sequence of discontinuous sandstone and pebbly sandstone strata interbedded with varying amounts of poorly stratified fine-grained rocks. The unit includes all of the Randlett horizon and the lower third of the Halfway horizon of Kay (1934). The new name Brennan Basin Member is proposed for this sequence, which is well exposed at Brennan Basin, on the Green River and in Halfway Hollow to the north.

The type section of the member extends from a small wash 700 feet east of the Green River, near the center of sec. 17, T. 7 S., R. 21 E. (Salt Lake Base Line), northward across Brennan Basin, along the Green River, up Twelvemile Wash to Halfway Hollow and up Halfway Hollow to the center of sec. 13, T. 5 S., R. 19 E. (Salt Lake Base Line), a distance of 17.2 miles (figure 2, section 3). The lithology of the type section is shown in figure 3b, section 3, and described in the appendix.

### Distribution and Thickness

The Brennan Basin Member is the most widespread unit of the Duchesne River Formation. It crops out from the Utah-Colorado state line to Currant Creek in an east-west trending strip up to 16 miles wide.

The member is 1,949 feet (594 m) thick in the type section. It thins westward to 726 feet (222 m) at Dry Gulch Creek and is 888.5 feet (270 m) thick at Rock Creek. Much of the change in thickness is probably related to differences in rates of deposition, and some may be the result of intertonguing with the underlying Uinta Formation and with the overlying Dry Gulch Creek Member. An unusually persistent marker bed, interpreted as a possible paleosol, found in the Halfway Hollow area indicates that the Brennan Basin Member interfingers with the overlying Dry Gulch Creek Member there, and that the uppermost part of the Brennan Basin Member is younger to the east.

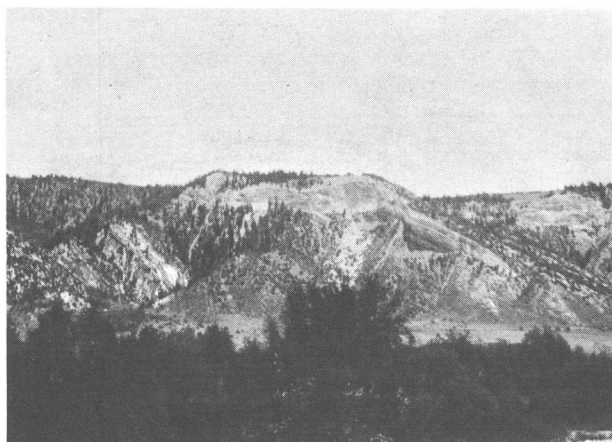


Figure 10. Starr Flat Member unconformably overlying tilted Permian and Triassic rocks along Lake Fork River, 26 miles north of Duchesne, Utah.

East of the type section, the Brennan Basin Member is at least 1,161 feet (354 m) thick at Asphalt Ridge. Farther east, erosion has removed much of the original deposit. The member thins to 422.5 feet (129 m) in the vicinity of Red Wash, Utah, and finally pinches out about 14 miles east of Red Wash.

### Lithology

In the type section, the Brennan Basin Member consists of approximately 60 percent sandstone, mostly yellowish gray or pale red in color and of medium grain size, and 40 percent fine-grained rocks, mostly reddish brown in color. Pebble conglomerate is present in less than 1 percent of the Brennan Basin Member in the type section. Thin-, thick- and very thick-bedded rocks are about equal in abundance. Nodular splitting is dominant, massive and blocky splitting are common, and slabby, flaggy or platy beds occur rarely. Horizontal and structureless stratification account for 65 percent of the beds. Most of the sandstone is in lenticular or cross-stratified tongues within fine-grained rocks (figures 11 and 12). Some fine-grained rocks are laminated, but most of them are extensively burrowed and show no apparent internal lamination (figure 13).

Cross section A-B (figure 3b) shows the major lateral variations in the Brennan Basin Member. West of the type section there is a marked increase in very thick-bedded, massive, cross-stratified sandstone (figure 14). The color of most of the sandstone darkens to yellowish brown and yellowish orange, and fine-grained sandstone is dominant in the west. Throughout most of the outcrop area, the Brennan Basin Member is distinguished by the presence of discontinuous, light colored sandstone beds that resist weathering and erosion more than the interbedded reddish brown, slope-forming fine-grained rocks.

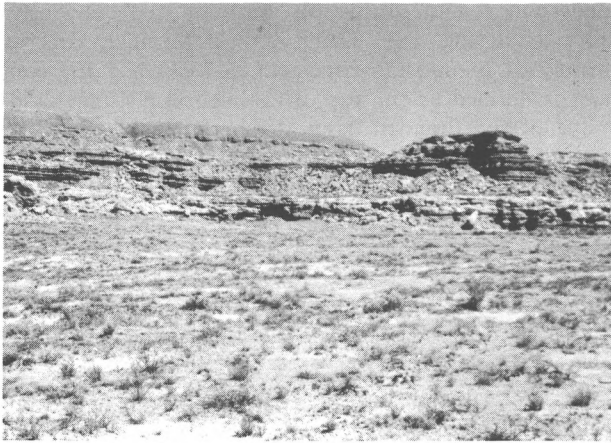


Figure 11. Typical exposure of Brennan Basin Member near Halfway Hollow.

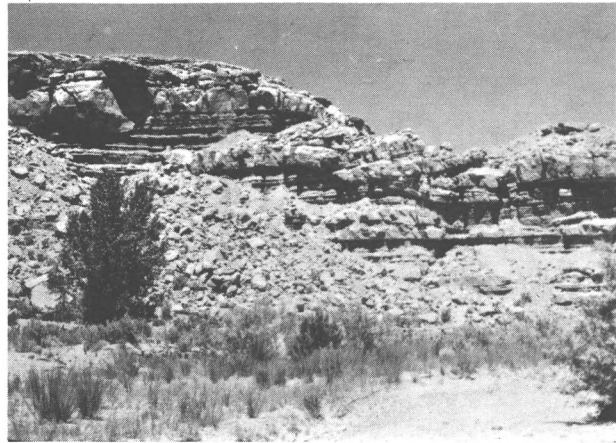


Figure 12. Laterally discontinuous sandstone lenses interbedded with fine-grained rocks in Brennan Basin Member near Twelvemile Wash.

#### Facies Changes

East of the type section, conglomerate and fine-grained rocks are more abundant. On Asphalt Ridge conglomerate comprises as much as 17 percent of the Brennan Basin Member. This part of the member is designated the conglomeratic facies and a reference section measured near Maeser, Utah, is described in the appendix. Conglomerate is present in thick lenses and in broad, persistent sheets that grade rapidly into finer material (figure 15). Maximum boulder size is 6 feet (1,830 mm) and the framework of the conglomerate is closed. Matrix is composed of sand, silt and clay, and lenses of sandstone are present within the conglomerate. Beds of conglomerate and coarse-grained sandstone are generally thick to very thick, massive to blocky, and form resistant cliffs and steep slopes. The beds are mixed with thin-bedded, slabby or flaggy fine-grained rocks that erode more easily. Lenticular and structureless stratification are typical of coarse beds. Imbri-

cation of coarse material is rare. Finer material is generally horizontally stratified and is locally very abundant in the lower part of the conglomeratic facies.

Abrupt lateral variation is characteristic of the Duchesne River Formation and it is especially pronounced in the conglomeratic facies of the Brennan Basin Member. Figure 4 illustrates the lateral variation in the facies along Asphalt Ridge. Numerous erosional surfaces are evident within the conglomeratic facies. They are conspicuous at the bases of most of the conglomerate beds and they also are present within thick sequences of conglomerate. Few surfaces of erosion persist laterally for more than 5,000 feet and most are more limited in extent. Basal relief is usually less than 5 feet, but local relief of some narrow channels may be as high as 20 feet. Conglomerate generally is present above the erosion surfaces, and the grain size of the rock decreases abruptly above the conglomerate. With decreasing grain size the bedding is thinner, more dis-



Figure 13. Mottled and burrowed, poorly stratified sandy claystone in Halfway Hollow. Scale = quarter.



Figure 14. Thick-bedded sandstone at base of Brennan Basin Member, 2 miles northwest of Ioka, Utah.

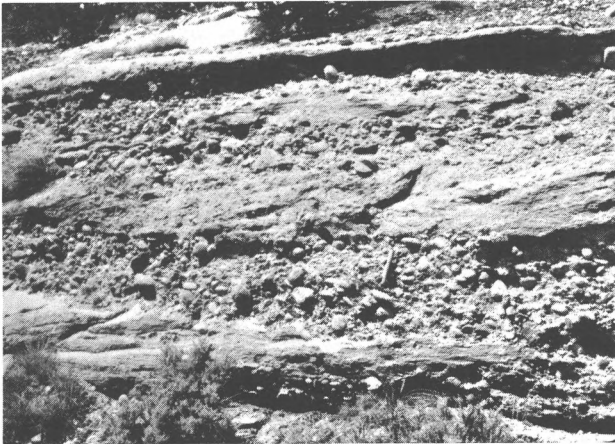


Figure 15. Laterally discontinuous conglomeratic sandstone, conglomeratic facies of Brennan Basin Member on Asphalt Ridge, 4 miles southwest of Vernal, Utah.

tinct and more persistent. Younger erosion surfaces are cut into these finer-grained beds and burrowing is sometimes conspicuous near the top of a sequence. Especially in the reference section, repetitive upward-fining sequences of variable thickness are conspicuous.

Figure 5 shows the transition from the conglomeratic facies on Asphalt Ridge (section 6) to the typical Brennan Basin Member near the Green River (section 3). Moderately persistent conglomeratic horizons on Asphalt Ridge grade southwestward into discontinuous lenses of sandstone in abundant fine-grained rocks.

#### Contacts

The base of the Brennan Basin Member over most of the outcrop area coincides with the base of the Duchesne River Formation. The contact with the

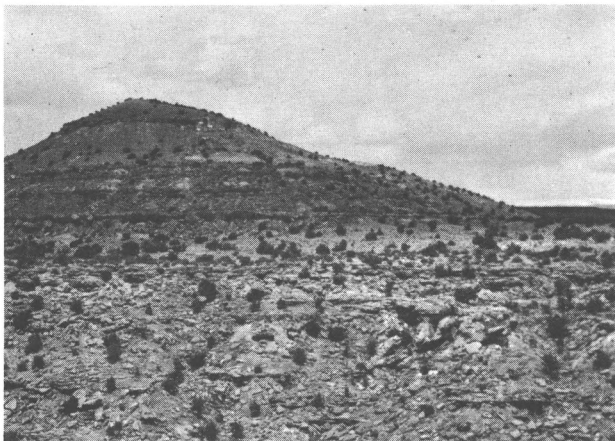


Figure 16. Fine-grained rocks of Dry Gulch Creek Member overlying sandstone of Brennan Basin Member near Dry Gulch Creek, 9 miles west of Roosevelt, Utah. Contact is at break in slope at top of sandstone in foreground.

underlying Uinta Formation was discussed previously. The overlying Dry Gulch Creek Member consists mainly of nonresistant fine-grained rocks and the contact is defined as the top of the highest resistant sandstone of the Brennan Basin Member (figure 16). In the west, this upward decrease in grain size coincides with an increase in reddish brown color, especially in the interbedded sandstones. Throughout the outcrop area, sandstones and fine-grained rocks of the Dry Gulch Creek Member are present as more widespread, persistent strata than those of the Brennan Basin Member.

#### Age and Correlation

A relatively diverse vertebrate fauna has been found in the Brennan Basin Member by several investigators. Most of the fossils are from a single quarry near the base of the unit about 2 miles northeast of Randlett, Utah. The following fossil list was compiled from original descriptions by Peterson (1931, 1932 and 1934), Clark (1932), Burke (1934a and b), Wood (*in* Scott, 1945) and Dawson (1966), with revisions suggested by Gazin (1955), Hough (1955) and Wood (1956). Additional specimens apparently have been found in this unit (Kay, 1934 and 1957), but have not been described.

#### Brennan Basin Member

##### Reptilia

##### Chelonia

*Cymatholcus longus* Clark

##### Crocodylia

*Crocodylus? acer* Cope

##### Mammalia

##### Lagomorpha

*Mytonolagus petersoni* Burke

##### Rodentia

*Leptomys kayi* Burke

?Sciuravid or Myomorph sp.

*Pareumys* sp.

*Protadajidaumo typus* Burke

*Mytonomys robustus* (Peterson) Wood

##### Carnivora

*Pleurocyon?* or *Uintacyon?* sp.

##### Perissodactyla

*Protitanotherium* sp.

*Dilophodon leotanus* (Peterson) Hough

*Epitriplopus medius* Peterson

*Mesamynodon medius* Peterson

*Megalamynodon regalis* Wood

##### Artiodactyla

*Pentacemylus progressus* Peterson

*Diplobunops crassus* Scott

*Protoreodon pumilus annectens* (Marsh) Gazin

*Protoreodon primus* (Peterson) Gazin

?*Hypertragulid* sp.

This fauna is closely related to that of the uppermost Uinta Formation, mostly known from a single quarry about 13 miles west of Randlett, near Myton, Utah. Indeed, Gazin (1959, p. 137) included this part of the Duchesne River Formation in the Uintan Stage. As discussed previously, the assemblage is now generally thought to indicate a late Eocene age.

## DRY GULCH CREEK MEMBER

### Name and Type Section

Conformably overlying the Brennan Basin Member and in part equivalent to it is a sequence of dominantly reddish brown sandstone and fine-grained rocks here named the Dry Gulch Creek Member. Dry Gulch Creek is a narrow drainage with excellent exposure to the west and northwest of the town of Roosevelt in Duchesne County, Utah.

The type section of the Dry Gulch Creek Member was measured from the top of a topographic bench at an elevation of 5,980 feet in sec. 7, T. 2 S., R. 2 W. (Uinta Base Line), 3,000 feet east of Dry Gulch Creek, northward to the top of the steep hillside in the northwest corner of sec. 32, T. 1 S., R. 2 W. (Uinta Base Line; figure 2, section 2). The lithologic sequence is summarized in figure 3b, section 2, and in the appendix.

### Distribution and Thickness

The Dry Gulch Creek Member crops out in a belt extending from Twelvemile Wash in the east to Rock Creek in the west. The width of the outcrop belt is generally 2 to 3 miles in a north-south direction and reaches a maximum of approximately 5 miles to the west of Dry Gulch Creek.

The thickness of the Dry Gulch Creek Member ranges from 659 feet (201 m) in the type section to 505.5 feet (154 m) in Halfway Hollow. It is the most uniformly thick unit in the formation.

### Lithology

The member in the type section consists of approximately 40 percent sandstone and 60 percent fine-grained rocks, especially silty claystone and claystone. Pebbly sandstone is rare and conglomerate is absent in the type section. Dominantly reddish brown, thick-bedded, slabby to massive, structureless, horizontally and cross-stratified sandstone beds are present as broad continuous sheets within which are numerous lenses and partings of fine-grained material. Sandstone strata are interbedded with thin- to thick-bedded, platy to blocky, horizontally stratified or laminated fine-grained

rocks. Discontinuous layers of bentonitic claystone impart a light greenish gray color to some of the fine-grained material. Thick-bedded, massive, cross-stratified sandstone generally increases in abundance westward (figure 17) and decreases eastward from the type section. The member is a nonresistant, slope-forming unit throughout most of the outcrop area, distinguished by its fine-grained nature and dominantly reddish brown color.



Figure 17. Reddish brown sandstone and fine-grained rocks of Dry Gulch Creek Member, 3 miles northeast of Roosevelt, Utah.

### Contacts

The base of the member is defined as the base of the lowest bed of fine-grained material overlying the highest resistant sandstone of the Brennan Basin Member. The Dry Gulch Creek Member is overlain by the Lapoint Member; the contact is located at the base of the lowest extensive, continuous, bentonitic bed of the Lapoint Member. In contrast to the lower boundary of the Dry Gulch Creek Member, its upper limit may be a relatively isochronous boundary.

### Age and Correlation

A sparse vertebrate fauna has been reported from the Dry Gulch Creek Member by Peterson (1932) and Scott (1945).

### Dry Gulch Creek Member

#### Mammalia

##### Carnivora

*Eosictis avinoffi* Scott

##### Perissodactyla

*Epihippus (Duchesnehippus)*  
*intermedius* Peterson

The occurrence of *Eosictis avinoffi* is limited to this member. It is assigned to the Felidae (Scott, 1945,

p. 218-219) and, if correctly placed, is significant as a very early member of the family in North America. *Epihippus (Duchesnehippus) intermedius* also may be present in the Lapoint Member (Kay, 1957), although the latter specimens have not been described. Future fossil discoveries in this member would be of considerable interest.

## LAPOINT MEMBER

### Name and Type Section

A sequence of reddish brown fine-grained rocks and sandstone interbedded with abundant greenish gray bentonitic beds overlies the Dry Gulch Creek Member (figure 18). This conspicuous sequence is the Lapoint horizon of Kay (1934) and the major bentonite member of Warner (1963). It is suggested that the earlier terminology be retained and formally applied to a slightly restricted section equivalent to nearly all of the Lapoint horizon of Kay. The type area of the Lapoint Member is in Twelvemile Wash, east and northeast of the town of Lapoint in Uintah County, Utah (Kay, 1934). A new reference section was measured from a small knoll in the north central portion of sec. 1, T. 5 S., R. 19 E. (Salt Lake Base Line), north of Utah State Highway 245, northward for 8,600 feet in Halfway Hollow to a short spur in the east central part of sec. 25, T. 4 S., R. 19 E. (figures 2 and 3a, section 3, and appendix).



Figure 18. Nonresistant fine-grained rocks and minor interbedded sandstone of Lapoint Member in Halfway Hollow, 3 miles northeast of Lapoint, Utah. Light colored beds consist of biotite-rich, bentonitic claystone.

### Distribution and Thickness

The Lapoint Member extends from Twelvemile Wash to Rock Creek in an outcrop belt roughly 2 to 4 miles wide. Because of relatively poor exposure of the nonresistant unit, its exact surface distribution is diffi-

cult to determine. The thickness of the Lapoint horizon was originally reported as 336 feet (Kay, 1934). To the west the member is 401.5 feet (122 m) thick in the reference section near Lapoint, Utah, and 1,045.5 feet (318 m) thick north of Roosevelt, Utah (figure 2). Farther west the upper portions of the member have been removed by erosion, but it is at least 222 feet (68 m) thick at Rock Creek.

### Lithology

Fine-grained rocks, including varieties of claystone, siltstone and mudstone, constitute about 60 percent of the Lapoint Member. Sandstone represents approximately 40 percent. Minor conglomerate is present in the reference locality, but was not observed in the member to the west. Stratification is largely indistinct, but where it is evident the unit is dominantly thin- to very thin-bedded and horizontally stratified or laminated. Nodular splitting is dominant, but well stratified rocks are platy or massive. In the vicinity of Rock Creek, the member becomes increasingly bentonitic and sandy. The interbedded sandstone is thick-bedded, blocky and structureless or cross-stratified.

The fine-grained bentonitic material in the Lapoint Member weathers and erodes readily. Exposures are generally poor and the Lapoint is typically represented by broad valleys and soft, relatively thick regolith. The light color of the fine-grained material is distinctive.

### Contacts

The contact of the Lapoint Member with the underlying Dry Gulch Creek Member is defined as the base of the lowest extensive bentonitic fine-grained bed. Warner (1963, p. 106) demonstrated that thick bentonitic beds in the upper part of the formation are relatively reliable markers for correlation. They probably formed through the alteration of volcanic ash and, therefore, approximate time planes. The lowest bentonitic layer of the Lapoint Member apparently is persistent and the base of the member may be a nearly isochronous boundary. The upper contact is located at the base of the lowest reddish brown sandstone or conglomerate overlying the highest greenish gray bentonitic claystone of the Lapoint Member; it is probably a time-transgressive boundary.

### Age and Correlation

Abundant fossil vertebrate remains were found in the original type locality of the Lapoint horizon in Twelvemile Wash (Kay, 1934). These and later discoveries assigned to the Lapoint horizon were taken from strata here designated the Lapoint Member. The

following fossil list is from the original descriptions by Burke (1934a), Peterson (1931, 1932 and 1934) and Black (1970), with changes suggested by Gazin (1955).

#### Lapoint Member

##### Reptilia

##### Crocodylia

*Crocodylus? acer* Cope

##### Mammalia

##### Insectivora

*Protictops alticuspidens* Peterson

##### Rodentia

*Leptotomus kayi* Burke

*Pareumys guensburgi* Black

*Protadjidaumo typus* Burke

##### Carnivora

*Hyaenodon* sp.

*Hessolestes ultimus* Peterson

##### Perissodactyla

*Teleodus Uintensis* Peterson

*Epitriplopus medius* Peterson

*Hyracodon primus* Peterson

*Mesamynodon medius* Peterson

##### Artiodactyla

*Pentacemylus progressus* Peterson

*Helohyus*<sup>1</sup> sp.

*Poabromylus kayi* Peterson

*Simimeryx minutus* (Peterson) Gazin

<sup>1</sup>Status uncertain, see Gazin, 1955, p. 5.

As with the other members, the Lapoint Member has doubtless yielded many fossils not listed here. Descriptions of these additional fossils and their locations, however, have not been published.

On the basis of similar faunas, a Duchesnean age has been assigned to part of the Sespe Formation near Pearson Ranch, California (Wilson, 1940), the lower part of the Tepee Trail Formation in Wyoming (Wood, 1949), part of the section at Sage Creek, Montana (Hough, 1955), the Norwood Tuff in Utah (Gazin, 1959), and the upper part of the Vieja Formation in Texas (DeFord, 1958). In most of these cases, however, the correlation has been questioned later by other workers (Radinsky, 1963; Black and Dawson, 1966a and b; Black, 1970; Nelson, 1971). The similarity of Uintan and Duchesnean faunas and the general paucity of fossils in all of these locations makes precise correlation difficult. In general, however, these units represent the latest Eocene deposits known in North America.

#### Economic Deposits

Elsewhere in the Rocky Mountain region bentonitic claystone contains economically important deposits of authigenic zeolites (Steven and Van Loenen,

1971). The minerals are useful as ion-exchangers and extremely selective molecular sieves. Large amounts of bentonitic material in the Lapoint Member make the unit a favorable place to look for zeolite minerals.

#### STARR FLAT MEMBER

##### Name and Type Section

The youngest member of the Duchesne River Formation is preserved only near the south margin of the Uinta Mountains. It is a sequence of coarse-grained sandstone and conglomerate here named the Starr Flat Member for outstanding exposures near John Starr Flat in Duchesne County, Utah.

The type section of the Starr Flat Member extends from the center of sec. 22, T. 1 N., R. 2 W. (Uinta Base Line), on the well exposed slope south of John Starr Flat, northwestward to the highest point on a prominent ridge at the boundary of secs. 34 and 35, T. 2 N., R. 3 W. (Uinta Base Line; figures 2 and 3a, section 2, and appendix).

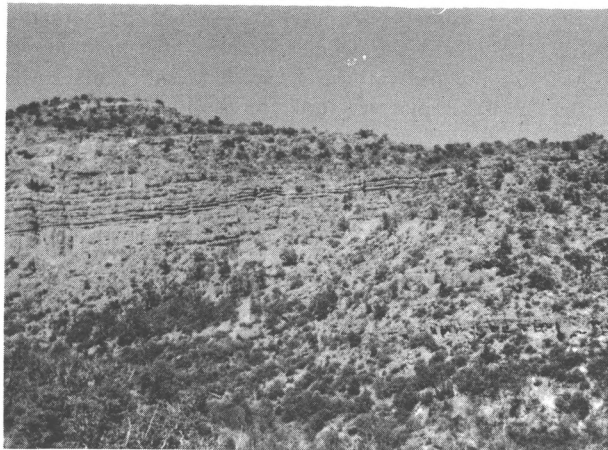
##### Distribution and Thickness

The Starr Flat Member overlaps the truncated edges of older deposits (figure 10) and extends up the flanks of the Uinta Mountains to an elevation of at least 8,000 feet above sea level. The member possibly reaches an elevation of nearly 11,000 feet locally. These beds are included as part of the Duchesne River Formation by several workers, but they have not been described in detail.

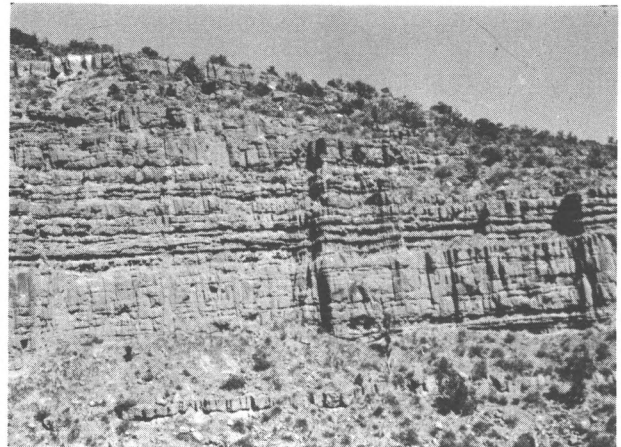
The Starr Flat Member is the remnant of a wedge of coarse clastic material that originally covered much of the south flank of the Uinta Mountains. Its present thickness is 769.5 feet (234 m) at Starr Flat. The member is only 124 feet (38 m) thick in Halfway Hollow and it thins markedly northward onto the Uinta Mountains. Its distribution is controlled primarily by modern erosion.

##### Lithology

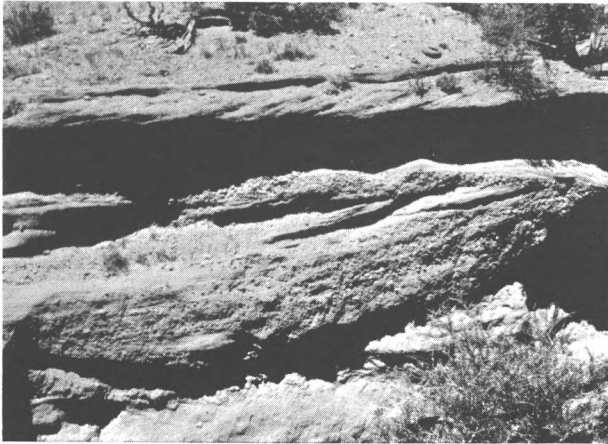
In the type section, the Starr Flat Member consists of approximately 75 percent sandstone, interbedded with roughly 20 percent fine-grained rocks and 5 percent conglomerate (figure 19). Thick bedding, massive to blocky splitting, and horizontal and cross-stratification are predominant. To the east in Halfway Hollow the unit becomes increasingly conglomeratic, very thick-bedded, massive and structureless. Persistent surfaces of erosion are rare within the member, but numerous minor breaks throughout indicate recurrent reworking and suggest that a large amount of time may



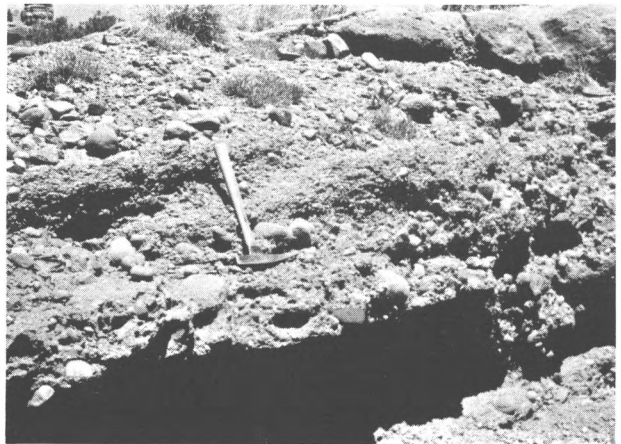
(A)



(B)



(C)



(D)

Figure 19. (A and B) Resistant sandstone of Starr Flat Member south of John Starr Flat, 14 miles north of Roosevelt, Utah. (C and D) Lenticular, conglomeratic sandstone of Starr Flat Member in Halfway Hollow, 6 miles northeast of Lapoint, Utah.

be represented by the deposits. Though generally poorly consolidated, the coarse clastic material in the Starr Flat Member forms steep slopes and cliffs.

#### Contacts

Coarse grain size and dark color distinguish the Starr Flat Member from the underlying Lapoint Member. The contact is at the base of the lowest reddish brown sandstone or conglomerate overlying the highest greenish gray, bentonitic claystone of the Lapoint Member. It probably is influenced largely by relationships with the source area and represents a facies transition that spans a considerable amount of time.

The upper part of the Starr Flat Member is covered in some places by younger gravels of various ages and origins, including the Browns Park Formation (Miocene ?) and a variety of glacial and proglacial deposits. The contact with these deposits is everywhere an erosional unconformity and can be identified by an abrupt upward decrease in degree of consolidation. In

general, the Starr Flat Member is darker than overlying beds. The age of the upper boundary of the member is probably extremely variable.

#### Age and Correlation

Fossils were not found in the Starr Flat Member, and none of the fossil localities described by previous workers are included within this interval. The precise age of the member is thus unknown, but is broadly bracketed by the underlying Lapoint Member (late Eocene) and the overlying Browns Park Formation. Future fossil discoveries in the Starr Flat Member would be of great interest and probably would extend the range of the Duchesne River Formation into the Oligocene Series.

#### SUMMARY OF STRATIGRAPHY

Vertical variations of bedding types and grain sizes in the Duchesne River Formation are summarized in figure 20. From the base upward to the Lapoint

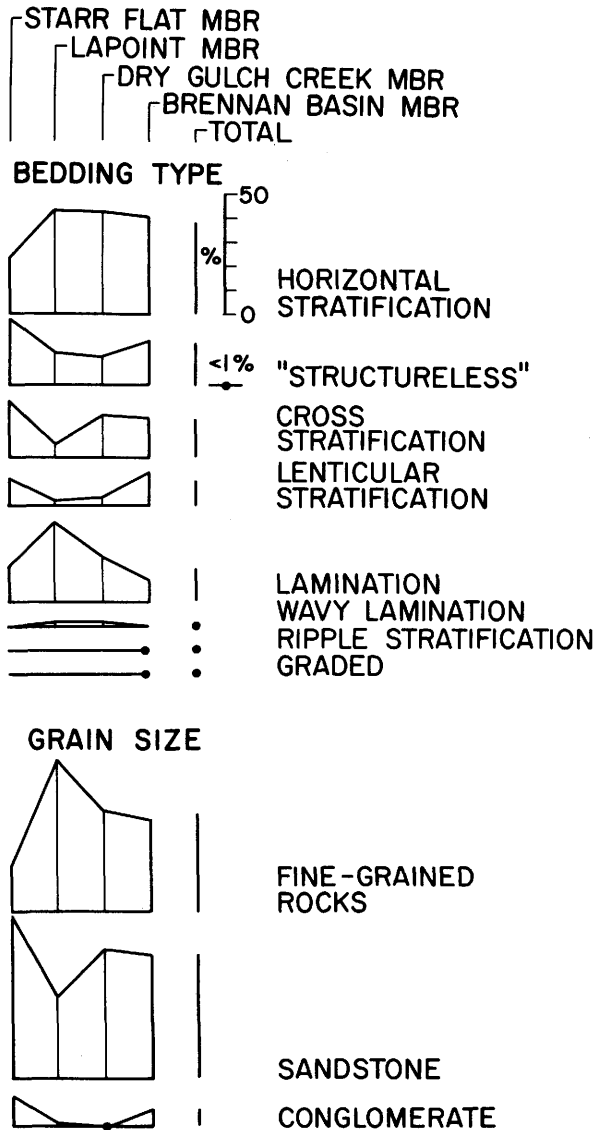


Figure 20. Vertical variations in bedding type and grain size from Brennan Basin to Starr Flat Member.

Member the rocks show a general decrease in structureless, lenticular and cross-stratification, and a corresponding increase in horizontal stratification and lamination. These changes are accompanied by a decrease in lenses and tongues of conglomerate and coarse-grained sandstone and an increase in thin, persistent beds of sandstone and fine-grained rocks. Above the Lapoint Member the rocks of the Starr Flat Member are exposed only near the Uinta Mountains. Probably partly because of the nearness of the source area, the beds show a reversed trend to increasing amounts of structureless, lenticular and cross-stratified conglomerate and sandstone, and reduced amounts of horizontally stratified and laminated fine-grained rocks.

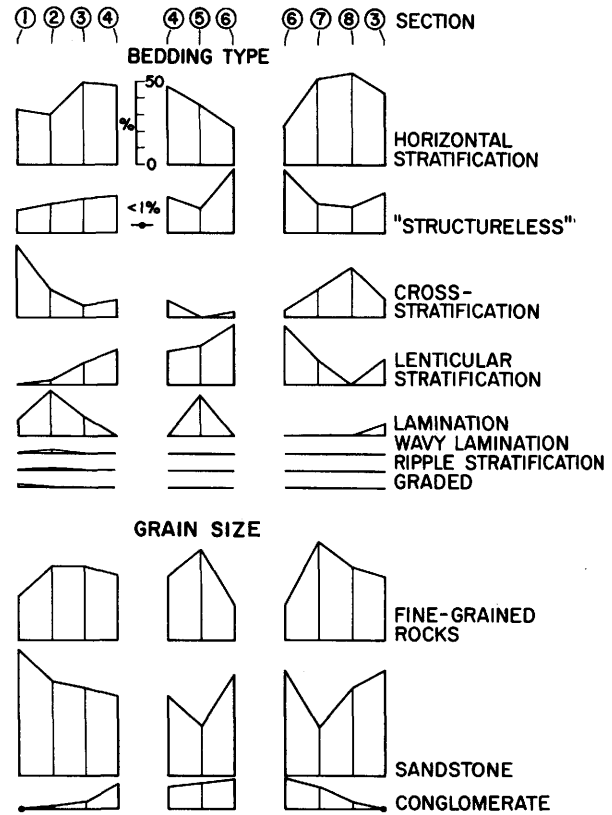


Figure 21. Lateral variations in bedding type and grain size in Duchesne River Formation. Three profiles correspond to cross sections of figures 3, 4 and 5.

Lateral variations in the character of the formation as a whole are summarized in figure 21. The three profiles in figure 21 correspond to the three cross sections of figures 3, 4 and 5. Profile A-B shows the gross variations from west to east along the present and original strike of the formation. From west to east cross-stratification and lamination decrease and horizontal, structureless and lenticular stratification increase. These changes reflect the decrease in persistent sheets of sandstone and the corresponding increase of poorly bedded conglomeratic sandstone lenses and fine-grained rocks from west to east.

Variations of more local extent in the Asphalt Ridge area are shown by profiles B-C and C-D. Consistent, significant trends are not prominent in profile B-C along Asphalt Ridge. In general, sections 4 and 6 are more similar to each other than to section 5 between them, illustrating the extreme variability of the heterogeneous conglomeratic facies exposed on the ridge. Profile C-D represents a traverse down the present direction of dip and along the original direction of transport. Structureless and lenticular stratification and conglomerate decrease in abundance, and horizontal and

cross-stratification increase with increasing distance of transport. Amounts of sandstone and fine-grained rocks vary less consistently.

Lateral variability within the formation is great, therefore, and the members are partly different facies whose times of formation overlap. As shown in cross sections B-C and C-D, extremely abrupt lateral changes are common in the Asphalt Ridge area, representing variations in lithology and bedding types and probably varying distance from the source area. The lateral changes from west to east along cross section A-B, in contrast, reflect differences in source material and environments along the front of the Uinta Mountains. The relationships between the Brennan Basin Member and the underlying Uinta Formation are obscure, but a diachronous boundary seems likely. The boundary between the Brennan Basin Member and overlying Dry Gulch Creek Member apparently represents a transgressive trend of the younger unit from west to east, at least in part of the area. The base of the Lapoint Member probably is a relatively isochronous boundary, but the ages of the base and highest exposures of the Starr Flat Member vary considerably from place to place. The vertical changes in the formation are more prominent than the lateral changes, and the four members are distinguished over a large area despite the lateral variability of the formation.

One of the significant problems encountered in late Eocene vertebrate biostratigraphy has been the extremely limited number of species in the standard Duchesnean fauna. Furthermore, although this fauna is readily distinguishable from that of the early Oligocene (Chadronian), it shares many important elements with the late Eocene Uintan fauna. Now that correlations throughout the Duchesne River Formation are possible, the search for vertebrate fossils can be extended to a much broader area than has been considered previously. Hopefully, new specimens will be found that will allow further definition of the latest Eocene fauna.

## CONDITIONS OF DEPOSITION

### General Setting

Because of the geometry of the Duchesne River Formation and of the individual beds within it, the suite of sedimentary structures, the wide range of grain sizes and poor sorting, and the presence of fossilized nonmarine vertebrates and plant remains, a fluvial environment of deposition of the Duchesne River Formation has been generally accepted by geologists (Peterson, 1932; Stagner, 1941; Clark, 1957; Covington, 1957; Jones, 1957; Untermann and Untermann, 1964; Warner, 1963, 1965 and 1966). Clark (1957) also noted that lacustrine deposits occur in parts of the formation.

### Climate and Relief

The late Eocene climate of most of the western United States is generally thought to have been warm and moist, resembling modern subtropical and warm temperate climates (Axelrod, 1966). On the basis of physical characteristics of the Green River Formation in Wyoming, Bradley (1929) reconstructed early Eocene climatic conditions in the Intermountain area. He concluded that Lake Gosiute existed in a seasonally variable, moist, warm temperate climate at an elevation of less than 1,000 feet in a basin of greater relief than the present Green River Basin in Wyoming.

More recently, MacGinitie (1969) restudied the flora of the Green River Formation from Wyoming, Utah and Colorado. The diverse flora indicates savanna conditions and rainfall in the warm season. Mixed floral elements from riparian, hillside and mountain valley settings reflect the topographic diversity of the area. Relief of the highlands over the lake basin may have been approximately 4,000 feet (MacGinitie, 1969, p. 35).

Although published descriptions of late Eocene floras in the Rocky Mountain region are few, floras of approximately Duchesnean age west of the Rocky Mountains indicate humid tropical coastal conditions and subtropical interior lowlands (Sanborn, 1937; Chaney, 1948). Moist, warm to cool temperate conditions existed in the interior highlands (Axelrod, 1966). Several recent studies of Eocene and Oligocene floras (Becker, 1960 and 1961; Axelrod, 1966; Axelrod and Bailey, 1969; Penny, 1969) indicate the presence of a montane forest assemblage mixed with the usual subtropical to warm temperate lowland vegetation types. Becker (1961) also noted the appearance of a subhumid slope element in Montana. The suggested variation of climate with elevation and existence of ranges more than 4,000 feet high (Axelrod, 1966, p. 49) indicate the Tertiary climatic patterns may have been more complicated than previously suspected (Chaney, 1940).

Within the Duchesne River Formation little evidence of local climatic conditions exists. Plant macrofossils consist mainly of unidentifiable fragments and the thoroughly oxidized deposits are barren of fossil pollen. Warner (1963, p. 45-46) listed several species of fossil vertebrates that he believed suggest a moderate or semitropical climate during Duchesnean time. In contrast, the few deposits observed during the present study that may represent paleosols are characterized by nodular concentrations of calcium carbonate, which generally form in moisture-deficient soils. The presence of coarse conglomerate and conglomeratic sandstone suggests relatively high gradients and high relief. The upland source area may thus have been considerably

cooler and wetter than the depositional site, and climatic indicators in the Duchesne River Formation may reflect a range of climatic conditions on the slopes of a relatively high Eocene mountain range.

#### Subenvironments

Within the general fluvial setting of the Duchesne River Formation several subenvironments are represented. Warner (1963, p. 83-84) described fossil oxbows and meanders, numerous irregular and filled-in channels, and abundant interbedded mudstones apparently deposited outside of major channels. In the present study, two major types of sandstone deposits are distinguished. The first type is characterized by a low width to thickness ratio (usually less than 10 to 1), and occurs generally as a single sand body with a sharply disconformable base and low to high erosional relief at the base (figure 22). Pebbly or conglomeratic sandstone at the base grades upward to cross-stratified, medium- or fine-grained sandstone. This type of sand body is interpreted as the deposit of a low-gradient, meandering stream channel and overlying point bar.

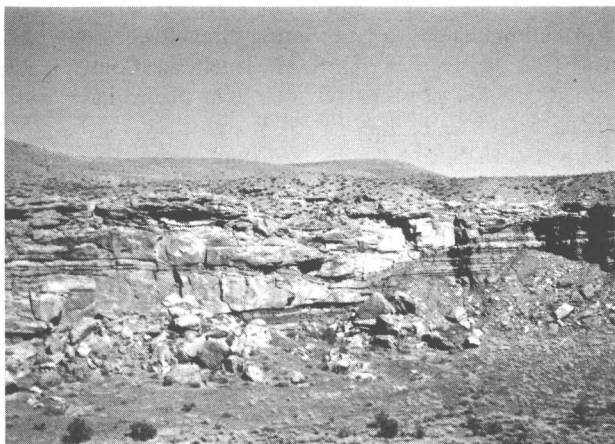


Figure 22. Sharply disconformable channel sandstone in Brennan Basin Member near Twelvemile Wash.

The second sandstone type has a high width to thickness ratio (often greater than 100 to 1), a disconformable to conformable base with low relief, and frequently contains lenses and beds of fine-grained material within the sand body (figure 14). The grain size may or may not decrease upward, but numerous poorly stratified, pebbly layers generally are present throughout. This type of sandstone is interpreted as the deposit of a high-gradient, braided stream, and resembles the multistory sand bodies interpreted by Wellman (1970, figure 9) to be braided stream deposits.

Fine-grained material (figure 23) probably was deposited on floodplains of both types of streams and on midchannel bars of braided streams. Most fine-

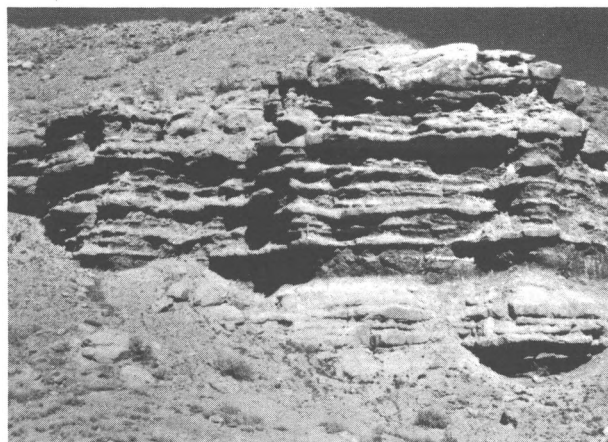


Figure 23. Irregularly stratified fine sandstone and fine-grained rocks of Brennan Basin Member in Twelvemile Wash.

grained deposits, especially those within braided channels, probably were stabilized by vegetation, and organic mixing has destroyed most of the original stratification. Fine-grained sediment probably accumulated both as laterally migrating bank deposits and as broadly distributed deposits of overbank floods, although the former type is probably volumetrically more important (Wolman and Leopold, 1957; Visher, 1965).

Further study is necessary to delineate the distribution of depositional environments within the Duchesne River Formation. The basic pattern apparently is that of a system of high-gradient braided streams near the source area, aggrading and probably advancing southward through time over a relatively flat floodplain traversed by low-gradient, meandering streams. Most of the formation was deposited by braided streams. The rate of uplift of the Uinta Mountains and aggradation in the Uinta Basin probably was greatest at the beginning and near the end of Duchesne River time (Andersen and Picard, 1972).

#### Paleocurrents

Directional sedimentary structures in the Duchesne River Formation include planar and trough cross-stratification, ripple marks, parting lineation and imbrication. Of these structures, medium-scale trough cross-stratification (McKee and Weir, 1953) is the most abundant (figures 24 and 25). From six to twenty-eight measurements of trough orientations were obtained at each of several localities and modal directions were established according to the method proposed by Tanner (1959). Most patterns are unimodal and the mode probably corresponds to the local down-slope direction. In many cases, minor secondary modes opposite or at right angles to primary modes are

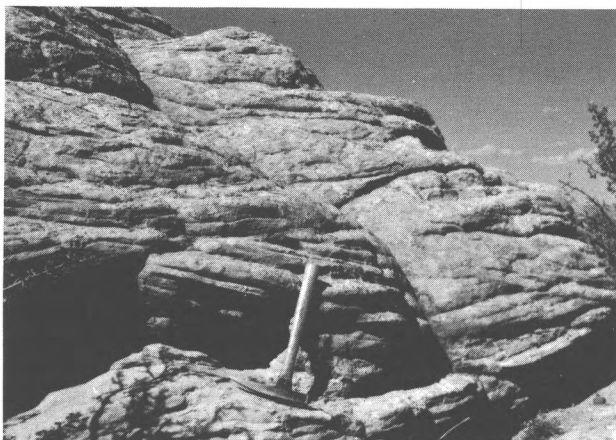


Figure 24. Medium-scale trough cross-stratification in Brennan Basin Member, 13 miles west of Roosevelt, Utah.

believed to reflect local changes in stream directions with time or complex flow patterns because of bars within channels.

Generally north to south drainage patterns prevailed during deposition of the Duchesne River Formation. This represents a major change from the east to west direction of flow of streams that deposited the underlying Uinta Formation (Stagner, 1941). Once the south-flowing streams were established, they persisted with little change throughout Duchesne River time and are still expressed in the present drainage pattern of the northern Uinta Basin.

The variability of trough orientations is different for sandstones with low and high width to thickness ratios. Cross-stratification directions in sandstones with low width-thickness ratios ( $\leq 10$ ), interpreted as deposits of low-gradient meandering streams, vary considerably from bed to bed and are generally less frequently unimodal than in sandstones with high width-thickness ratios ( $\geq 100$ ), which are interpreted as deposits of high-gradient, braided streams. Braided stream deposits are more commonly unimodal and modal directions are more consistent over large areas, but the scatter of cross-stratification directions within modes is greater than in deposits of meandering streams. Sandstones with intermediate width-thickness ratios (10 to 100) show intermediate characteristics and probably represent mixtures of the two stream types or transitions between them.

#### OIL-IMPREGNATED SANDSTONE

The significant oil-impregnated sandstone deposits of Asphalt Ridge, Ts. 4, 5 and 6 S., Rs. 20, 21 and 22 E., (S.L.M.), near Vernal, Utah, occur partly in the basal part of the Brennan Basin Member and partly in the underlying Mesaverde Group (Cretaceous). This extensive resource has supplied asphalt to Uintah



Figure 25. Medium-scale, low-angle trough cross-stratification in Brennan Basin Member, 7 miles east of Randlett, Utah.

County since 1895 and contains approximately 1.8 to 2.0 billion barrels of oil in place (H. R. Ritzma, 1972, personal communication). About 55 percent of this is in sandstones in the Brennan Basin Member.

Three much smaller deposits of oil-impregnated sandstone also are known from the Duchesne River Formation. These are at Spring Branch (NW NE sec. 24, T. 2 N., R. 3 W., U. S. M., Duchesne County), 3.8 to 4.0 million gross barrels of oil in place; Lake Fork (secs. 5 and 6, T. 1 N., R. 4 W., and sec. 1, T. 1 N., R. 5 W., U. S. M., Duchesne County), 6.9 to 9.5 million barrels; and Littlewater Hills (Ts. 1 and 2 N., Rs. 1 and 2 E., U. S. M., and sec. 34, T. 3 S., R. 19 E., S. L. M., Uintah County), 8.2 to 11.7 million barrels (H. R. Ritzma, 1972, personal communication). All three of these occurrences are in the Starr Flat Member.

It is unlikely that any of the oil found in these deposits originated in the Duchesne River Formation. Rather, the Duchesne River has entrapped oil migrating up dip from lacustrine beds of the Green River Formation. The oil-impregnated sandstone deposits in the Starr Flat Member are the youngest deposits of any significance in the Uinta Basin. Thus, they indicate that substantial migration of oil, previously entrapped elsewhere, took place after deposition and lithification of the Duchesne River Formation.

#### CONCLUSIONS

On the basis of lithology, splitting characteristics and bedding types, the Duchesne River Formation is subdivided into four lithostratigraphic units. The names Brennan Basin, Dry Gulch Creek, Lapoint and Starr Flat members are proposed for these units. The boundaries, with the possible exception of the base of the Lapoint Member, are probably time-transgressive, but the members include the entire formation and can be identified over large areas.

The presence of traceable lithostratigraphic units should encourage exploration for new fossil localities throughout the formation. Further discoveries will greatly improve the understanding of the typical fauna of the Duchesnean Age.

Bentonitic claystones are widespread in the formation. They are a potentially useful source of material for radiometric dating. They also may contain economically significant mineral deposits.

Clastic sedimentary rocks in the Duchesne River Formation range in grain size from boulder conglomerate to claystone and in composition from lithic to quartzose. Lithic types are the most abundant. Composition varies with grain size, location and stratigraphic position.

Within the dominantly fluvial sequences of the Duchesne River Formation two types of stream deposits are distinguished. Upward-fining sand bodies with low width to thickness ratios are interpreted as deposits of low-gradient, meandering streams. More commonly sand bodies are conglomeratic with high width to thickness ratios and they may or may not become finer-grained in their upper parts. These are interpreted as deposits of high-gradient, braided streams. Transitional types and fine-grained plain deposits also are present.

Paleocurrent directions are reconstructed from trough cross-stratification orientations. Generally southward directions of flow are indicated, but variability is greater than previously suspected. Variability of paleocurrent directions is related to the other characteristics of the sand bodies.

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APPENDIX

Brennan Basin Member

Type section of Brennan Basin Member; measured from small wash 700 feet east of the Green River, near the center of sec. 17, T. 7 S., R. 21 E. (Salt Lake Base Line), northward across Brennan Basin, along the Green River, up Twelvemile Wash to Halfway Hollow, and up Halfway Hollow to the center of sec. 13, T. 5 S., R. 19 E. (Salt Lake Base Line).

Top of section; unit overlain by reddish brown (10R4/4) clayey siltstone of Dry Gulch Creek Member.

	Feet
33. Sandstone, pebbly, yellowish gray (5Y8/2), very thick-bedded, massive, cross-stratified, poorly sorted, coarse-grained, sublithic . . . . .	25.0
32. Siltstone, sandy, pale reddish brown (10R5/4) and moderate yellowish brown (10YR5/4), thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	47.5
31. Limestone, sandy and clayey, grayish red purple (5RP4/2), thin-bedded, slabby, structureless, medium to coarsely crystalline (0.08-0.40mm) . .	1.0
30. Siltstone, yellowish brown (10YR5/2), very thin-bedded, nodular, horizontally stratified, moderately sorted . . . . .	13.0
29. Sandstone, pebbly, yellowish gray (5Y7/2), thick-bedded, blocky, structureless, moderately sorted, fine-grained, sublithic, erosion at base with low relief; interbedded with siltstone, sandy, dark reddish brown (10R3/4), very thin-bedded, nodular, horizontally stratified, poorly sorted . .	17.5
28. Claystone, silty and sandy, light greenish gray (10Y7/1) and reddish brown (10R4/4), very thin-bedded, platy, laminated, poorly sorted, burrowed near top; interbedded with sandstone, moderate reddish brown (10R4/6), thin-bedded, flaggy, laminated, moderately sorted, fine-grained, quartzose; and sandstone, light gray (N7), very thick-bedded, massive, structureless, poorly sorted, medium-grained, sublithic . . . . .	93.0
27. Sandstone, yellowish gray (5Y7/2), very thick-bedded, massive, structureless, poorly sorted, medium-grained, sublithic; interbedded with sandstone, silty, moderate yellowish brown (10YR5/4), thin-bedded, nodular, horizontally stratified, poorly sorted, very fine-grained, quartzose; and siltstone, dark reddish brown (10R3/4), very thin-bedded, nodular, laminated, moderately sorted . . . . .	59.5
26. Claystone, silty, yellowish gray (5Y7/2) and light olive gray (5Y5/2), thin-bedded, nodular, horizontally stratified, poorly sorted; with lenses of sandstone, light gray (N7), thin-bedded, friable, structureless, poorly sorted, medium-grained, sublithic . . . . .	34.5
25. Sandstone, pebbly, and pebble conglomerate, yellowish gray (5Y8/1), very thick-bedded, massive, lenticularly stratified, poorly sorted, coarse-	

grained, lithic, erosion at base with 15 feet relief, base of Halfway horizon of Kay (1934); grades upward to sandstone, pale reddish brown (10R5/6) and yellowish gray (5Y7/2), thick-bedded, blocky, cross-stratified, poorly sorted, medium-grained, sublithic; interbedded with siltstone, sandy, pale reddish brown (10R5/4), thick-bedded, blocky, structureless, poorly sorted .	63.0
24. Sandstone, yellowish gray (5Y7/2), very thick-bedded, massive, structureless, poorly sorted, coarse-grained, sublithic, erosion at base with 5 feet relief; grades upward to sandstone, silty, yellowish gray (5Y7/2), thick-bedded, blocky, horizontally stratified, poorly sorted, fine-grained, sublithic; interbedded with siltstone, sandy, pale reddish brown (10R5/4) and moderate yellowish brown (10YR5/4), very thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	93.5
23. Sandstone, yellowish gray (5Y8/2), thick-bedded, blocky, horizontally stratified, moderately sorted, fine-grained, quartzose; interbedded with siltstone, sandy, grayish red (10R4/2), thin-bedded, nodular, horizontally stratified, poorly sorted . .	115.0
22. Siltstone, sandy, greenish yellow (10Y7/2), thin-bedded, slabby, horizontally stratified, poorly sorted; interbedded with sandstone, silty, grayish red (10R5/2), very thick-bedded, massive, structureless, poorly sorted, fine-grained, sublithic . .	79.5
21. Sandstone, yellowish gray (5Y7/2), very thick-bedded, massive, structureless, poorly sorted, medium-grained, sublithic, erosion at base with 3 feet relief; grades upward to siltstone, sandy, reddish brown (10R4/4) and pale red (10R6/2), thin-bedded, slabby, lenticularly stratified, poorly sorted . . . . .	65.5
20. Sandstone, pebbly, yellowish gray (5Y7/2), very thick-bedded, massive, cross-stratified, poorly sorted, coarse-grained, sublithic, erosion at base with 10 feet relief; grades upward to claystone, moderate reddish brown (10R4/6), thin-bedded, nodular, horizontally stratified, moderately sorted.	102.5
19. Mudstone, sandy, reddish brown (10R4/4), thin-bedded, nodular, horizontally stratified, poorly sorted, burrowed; interbedded with sandstone, silty, greenish yellow (10Y7/2), thin-bedded, nodular, horizontally stratified, poorly sorted, fine-grained, sublithic; with lenses of sandstone, pebbly, yellowish gray (5Y8/2), thin-bedded, slabby, cross-stratified, poorly sorted, coarse-grained, lithic . . . . .	71.5
18. Sandstone, pebbly, greenish yellow (10Y7/2), very thick-bedded, massive, structureless, poorly sorted, coarse-grained, lithic, erosion at base with low relief; grades upward to siltstone, sandy and clayey, pale orange (10YR7/2), thin-bedded, nodular, horizontally stratified, poorly sorted. . .	93.5
17. Sandstone, silty, moderate brown (5YR4/4), thick-bedded, nodular, structureless, poorly sorted, very fine-grained, sublithic; grades upward	

	to claystone, greenish yellow (10Y7/2), very thin-bedded, nodular, laminated, moderately sorted.	51.0	dark yellowish orange (10YR6/6), very thin-bedded, nodular, laminated, moderately sorted . .	33.0
16.	Sandstone, light gray (N7.5), thick-bedded, friable, structureless, poorly sorted, medium-grained, sublithic, erosion at base with 15 feet relief; interbedded with siltstone, sandy, moderate reddish brown (10R4/6), thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	67.0	7. Sandstone, grayish yellow (5Y8/4), thick-bedded, massive, structureless, moderately sorted, medium-grained, sublithic, erosion at base with 5 feet relief; grades upward to siltstone, sandy, grayish red (10R4/2) and yellowish gray (5Y7/2), thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	18.0
15.	Sandstone, pebbly, grayish yellow (5Y8/4), thick-bedded, blocky, structureless, poorly sorted, coarse-grained, sublithic, erosion at base with low relief; grades upward to siltstone, sandy, grayish red (10R5/2), thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	23.0	6. Siltstone, clayey, grayish yellow green (5GY7/2), yellowish gray (5Y7/2) and pale yellowish brown (10YR6/2), thin-bedded, slabby, horizontally stratified, poorly sorted; with lenses of sandstone, very light gray (N8), thin-bedded, slabby, structureless, moderately sorted, medium-grained, sublithic . . . . .	34.5
14.	Sandstone with lenses of pebble conglomerate, yellowish gray (5Y7/2), thick-bedded, blocky, lenticularly stratified, poorly sorted, medium-grained, sublithic; grades upward to siltstone, grayish red (10R4/2), thin-bedded, nodular, laminated, moderately sorted . . . . .	57.0	5. Claystone, sandy, dusky red (10R3/2), thin-bedded, nodular, laminated, poorly sorted; with lenses of sandstone, pale orange (10YR7/2) and yellowish gray (5Y7/2), thick-bedded, blocky, structureless, poorly sorted, coarse-grained, lithic . . . . .	42.0
13.	Sandstone, yellowish gray (5Y7/2), very thick-bedded, massive, cross-stratified, poorly sorted; medium-grained, sublithic, erosion at base with 10 feet relief; grades upward to claystone, silty, moderate reddish brown (10R4/6), thin-bedded, nodular, laminated, poorly sorted . . . . .	50.0	4. Sandstone, yellowish gray (5Y7/2), thick-bedded, blocky, horizontally stratified, poorly sorted, coarse-grained, sublithic; grades upward to siltstone, grayish red (10R4/2), thin-bedded, slabby, horizontally stratified, moderately sorted; interbedded with sandstone, light brown (5YR6/4), thick-bedded, blocky, horizontally stratified, moderately sorted, medium-grained, sublithic . . . . .	94.5
12.	Sandstone, silty, grayish yellow green (5GY7/2) and yellowish gray (5Y7/2), thick-bedded, blocky, lenticularly stratified, poorly sorted, fine-grained, sublithic; interbedded with siltstone, grayish red (10R4/2), thin-bedded, nodular, horizontally stratified, moderately sorted . . . . .	43.0	3. Sandstone, pale red (10R6/2), very thick-bedded, massive, horizontally stratified, poorly sorted, medium-grained, sublithic; grades upward to claystone, sandy and silty, reddish brown (10R4/4), thin-bedded, nodular, laminated, poorly sorted . . . . .	78.5
11.	Sandstone, yellowish gray (5Y8/1), very thick-bedded, massive, structureless, moderately sorted, medium-grained, sublithic, erosion at base with 10 feet relief; grades upward to sandstone, pebbly, yellowish gray (5Y7/2), thick-bedded, blocky, cross-stratified, poorly sorted, coarse-grained, lithic . . . . .	41.0	2. Claystone, silty, dark reddish brown (10R3/4) and grayish yellow green (5GY7/2), thin-bedded, nodular, horizontally stratified, poorly sorted; with lenses of sandstone, silty, yellowish gray (5Y7/2), thin-bedded, friable, lenticularly stratified, poorly sorted, fine-grained, sublithic . . . . .	77.0
10.	Claystone, silty, dusky yellow (5Y6/4), yellowish gray (5Y8/2) and moderate reddish brown (10R4/6), thin-bedded, nodular, horizontally stratified, poorly sorted; with lenses of sandstone, grayish yellow (5Y8/4), very thick-bedded, massive, cross-stratified, poorly sorted, medium-grained, lithic . . . . .	98.5	1. Sandstone, yellowish gray (5Y8/1), thick-bedded, blocky, cross-stratified, poorly sorted, medium-grained, lithic, erosion at base with 3 feet relief; interbedded with siltstone, dark reddish brown (10R3/4), thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	30.0
9.	Sandstone, yellowish gray (5Y7/2), thick-bedded, blocky, lenticularly stratified, poorly sorted, medium-grained, lithic, erosion at base with 20 feet relief; interbedded with siltstone, pale olive (10Y6/2) and moderate reddish brown (10R4/6), very thin-bedded, nodular, laminated, moderately sorted . . . . .	136.0	Total thickness of Brennan Basin Member . . . . .	1,949.0
8.	Sandstone, silty, very light gray (N8), thick-bedded, blocky, structureless, poorly sorted, medium-grained, sublithic, erosion at base with 6 feet relief; grades upward to sandstone, silty, very light gray (N8), thin-bedded, nodular, horizontally stratified, poorly sorted, very fine-grained, sublithic, burrowed; interbedded with siltstone, moderate reddish brown (10R4/6) and		Base of section; unit overlies grayish red purple (5RP4/2) silty claystone of Uinta Formation (Eocene).	
			Brennan Basin Member	
			Reference section of conglomeratic facies of Brennan Basin Member; location in NW¼ sec. 31, T. 4 S., R. 21 E. (Salt Lake Base Line), at north end of Asphalt Ridge, 1.7 miles southwest of Maeser, Uintah County, Utah; base of section 500 feet south of Uintah County asphalt pit at base of Asphalt Ridge, measured eastward up the ridge for 1,700 feet.	
			Top of section; unit overlain by yellowish gray (5Y7/2) sandstone and pale reddish brown (10R5/6) siltstone of sandy facies of Brennan Basin Member.	

Feet	Dry Gulch Creek Member
<p>7. Pebble conglomerate, grayish orange (10YR7/4), thick-bedded, massive, lenticularly stratified, poorly sorted, lithic, erosion at base with low relief; grades upward to sandstone, pebbly, yellowish gray (5Y7/2), thin-bedded, blocky, structureless, poorly sorted, coarse-grained, lithic . . . . .</p>	<p>Type section of Dry Gulch Creek Member; base of section at topographic bench, elevation 5,980 feet, in NE¼ SW¼ sec. 7, T. 2 S., R. 2 W. (Uinta Base Line), measured northward to top of hill in NW¼ NW¼ sec. 32, T. 1 S., R. 2 W. (Uinta Base Line).</p>
27.5	
<p>6. Boulder conglomerate, yellowish gray (5Y7/2) and grayish orange (10YR7/4), thick-bedded, massive, lenticularly stratified, poorly sorted, lithic, erosion at base with 10 feet relief; grades upward to sandstone, pebbly, yellowish gray (5Y7/2), thin-bedded, blocky, lenticularly stratified, poorly sorted, coarse-grained, lithic; grades upward to sandstone, yellowish gray (5Y7/2), thin-bedded, slabby, structureless, poorly sorted, fine-grained, lithic; grades upward to mudstone, silty, and siltstone, clayey, moderate reddish brown (10R4/6) and greenish yellow (10Y7/2), thin-bedded, flaggy, horizontally stratified, poorly sorted . . . . .</p>	<p>Top of section; unit overlain by light olive gray (5Y5/2) sandy mudstone of Lapoint Member.</p>
102.5	
<p>5. Cobble conglomerate, yellowish gray (5Y7/2), thick-bedded, massive, lenticularly stratified, poorly sorted, lithic, erosion at base with 2 feet relief; grades upward to sandstone, yellowish gray (5Y7/2), thin-bedded, blocky, structureless, poorly sorted, medium-grained, lithic; grades upward to sandstone, silty, greenish yellow (10Y7/2), thin-bedded, nodular, horizontally stratified, poorly sorted, fine-grained, sublithic, burrowed . . . . .</p>	<p>14. Sandstone, pale red (10R6/2), very thick-bedded, blocky, horizontally stratified, poorly sorted, coarse-grained, sublithic; interbedded with claystone, very dusky red (10R2/2) and dark greenish gray (5GY4/1), thin-bedded, platy, horizontally stratified, moderately sorted . . . . .</p>
92.0	44.0
<p>4. Cobble conglomerate, yellowish gray (5Y7/2), thick-bedded, massive, lenticularly stratified, poorly sorted, lithic, erosion at base with low relief; grades upward to sandstone, yellowish gray (5Y7/2), thin-bedded, blocky, structureless, poorly sorted, medium-grained, lithic . . . . .</p>	<p>13. Claystone, silty, grayish red (10R4/2), dark yellowish brown (10YR3/2) and light olive gray (5Y6/1), thick-bedded, platy, horizontally stratified, poorly sorted, micaceous . . . . .</p>
50.0	107.0
<p>3. Siltstone, yellowish brown (10YR6/4), yellowish gray (5Y7/2) and light brown (5YR5/6), thick-bedded, flaggy, horizontally stratified, moderately sorted, micaceous . . . . .</p>	<p>12. Sandstone, light olive gray (5Y6/1), thin-bedded, friable, horizontally stratified, poorly sorted, fine-grained, lithic, micaceous; grades upward to sandstone, pale red (10R6/2), thick-bedded, blocky, horizontally stratified, moderately sorted, medium-grained, sublithic . . . . .</p>
57.0	24.5
<p>2. Sandstone, pebbly, yellowish gray (5Y7/2), thick-bedded, blocky, structureless, poorly sorted, medium- to coarse-grained, sublithic; interbedded with siltstone, sandy, light gray (N7) and moderate reddish brown (10R4/6), thin-bedded, slabby, horizontally stratified, poorly sorted, micaceous . . . . .</p>	<p>11. Sandstone, silty, pale yellowish brown (10YR6/2), thick-bedded, massive, horizontally stratified, poorly sorted, medium-grained, sublithic; grades upward to sandstone, silty, pinkish gray (5YR8/1), thin-bedded, slabby, horizontally stratified, poorly sorted, very fine-grained, quartzose . . . . .</p>
80.0	30.0
<p>1. Pebble conglomerate, light gray (N7) and pale grayish orange (10YR8/4), very thick-bedded, massive, lenticularly stratified, poorly sorted, lithic, erosion at base with 3 feet relief; with lenses of sandstone, silty, moderate reddish orange (10R6/6), thin-bedded, slabby, lenticularly stratified, poorly sorted, medium-grained, sublithic . . . . .</p>	<p>10. Claystone, silty, grayish red (5R4/2) and greenish gray (5GY5/1), thick-bedded, platy, laminated, poorly sorted . . . . .</p>
11.5	39.0
<p>Partial thickness of Brennan Basin Member . . . . .</p>	<p>9. Sandstone, pale red (10R6/2), thick-bedded, blocky, cross-stratified, poorly sorted, medium-grained, quartzose, erosion at base with 3 feet relief . . . . .</p>
420.5	54.0
<p>Base of section; unit overlies very light gray (N8) sandstone of Rimrock Sandstone of Mesaverde Group (Cretaceous).</p>	<p>8. Sandstone, pale red (10R6/2), thick-bedded, slabby, structureless, moderately sorted, medium-grained, quartzose; interbedded with claystone, silty, pale brown (5YR5/2) and light olive (10Y5/2), thin-bedded, friable, horizontally stratified, poorly sorted . . . . .</p>
	50.0
	<p>7. Sandstone, grayish orange (10YR7/4), thick-bedded, blocky, cross-stratified, moderately sorted, coarse-grained, quartzose, erosion at base with 2 feet relief; grades upward to siltstone, sandy, moderate brown (5YR4/4) and dark yellowish brown (10YR4/2), thin-bedded, nodular, laminated, poorly sorted, quartzose . . . . .</p>
	17.5
	<p>6. Claystone, silty, and claystone, dark yellowish brown (10YR4/2), very dusky red (10R2/2), grayish yellow (5Y8/4) and pale yellowish brown (10YR6/2), very thin-bedded, platy, laminated, moderately to poorly sorted, contains locally abundant plant remains . . . . .</p>
	30.0

5. Sandstone, pale yellowish brown (10YR6/2), thick-bedded, blocky, structureless, poorly sorted, medium-grained, sublithic; interbedded with sandstone, silty, dark yellowish brown (10YR4/2), thin-bedded, nodular, laminated, poorly sorted, very fine-grained, sublithic . . . . .	18.0	stratified, poorly sorted, medium-grained, lithic, micaceous . . . . .	8.0
4. Sandstone, grayish orange (10YR7/4), very thick-bedded, massive, cross-stratified, moderately sorted, medium-grained, quartzose, erosion at base with low relief . . . . .	15.0	8. Pebble conglomerate, grayish orange (10YR7/4), very thick-bedded, massive, lenticularly stratified, poorly sorted, lithic, erosion at base with low relief; grades upward to sandstone, grayish orange (10YR7/4), thick-bedded, blocky, cross-stratified, poorly sorted, coarse-grained, lithic . . . . .	41.5
3. Claystone, silty, dusky brown (5YR2/2), moderate yellowish brown (10YR5/4) and greenish gray (5GY6/1), thin-bedded, slabby, laminated . .	101.0	7. Siltstone, sandy, moderate reddish brown (10R4/6), thin-bedded, nodular, horizontally stratified, poorly sorted; interbedded with sandstone, pebbly, light brown (5YR6/4) and pale reddish brown (10R5/6), thick-bedded, blocky, structureless, poorly sorted, coarse-grained, lithic .	62.0
2. Sandstone, pale yellowish brown (10YR6/2), very thick-bedded, massive, structureless, poorly sorted, coarse-grained, sublithic, erosion at base with 2 feet relief; interbedded with siltstone, clayey, light brown (5YR6/4) and very dusky red purple (5RP2/2), thin-bedded, slabby, laminated, poorly sorted . . . . .	80.0	6. Claystone, pale red (5R6/2) and dusky red (10R3/2), very thin-bedded, nodular, laminated, moderately sorted . . . . .	22.5
1. Claystone, silty, grayish red (5R4/2), moderate yellowish brown (10YR5/4) and greenish gray (5GY6/1), thin-bedded, nodular, wavy-laminated, poorly sorted . . . . .	49.0	5. Claystone, silty, greenish gray (5G5/1), thin-bedded, nodular, horizontally stratified, poorly sorted; grades upward to siltstone, pale reddish brown (10R5/4), thin-bedded, slabby, horizontally stratified, poorly sorted; grades upward to sandstone, pebbly, light brown (5YR5/6), thick-bedded, friable, structureless, poorly sorted, coarse-grained, sublithic . . . . .	26.5
Total thickness of Dry Gulch Creek Member . . . . .	659.0	4. Sandstone, silty, pale reddish brown (10R5/4) and light brown (5YR5/6), thin-bedded, slabby, horizontally stratified, poorly sorted, very fine-grained, sublithic; with lenses of sandstone, pebbly, light brown (5YR5/6), thick-bedded, friable, structureless, poorly sorted, coarse-grained, sublithic . . . . .	20.5
Base of section; unit overlies grayish orange pink (10R8/2) sandstone of Brennan Basin Member.		3. Claystone, sandy, greenish gray (5G5/1) and pale brown (5YR5/2), thin-bedded, nodular, horizontally stratified, poorly sorted . . . . .	22.5

### Lapoint Member

Reference section of Lapoint Member; base of section at base of small knoll north of Utah State Highway 245 in the north central portion of sec. 1, T. 5 S., R. 19 E. (Salt Lake Base Line), measured northward for 8,600 feet in Halfway Hollow to a short spur in the east central part of sec. 25, T. 4 S., R. 19 E. (Salt Lake Base Line).

Top of section; unit unconformably overlain by pale reddish brown (10R5/6) cobble conglomerate of Starr Flat Member.

	Feet		
12. Claystone, silty, pale olive (10Y6/2) and grayish red (10R4/2), thin-bedded, nodular, horizontally stratified, poorly sorted; interbedded with sandstone, light gray (N7.5), thin-bedded, slabby, horizontally stratified, poorly sorted, medium-grained, lithic . . . . .	91.5	1. Claystone, silty, greenish gray (5G5/1), very thin-bedded, flaggy, horizontally stratified, poorly sorted, micaceous; interbedded with sandstone, silty, pale brown (5YR5/2) and light gray (N7), thin-bedded, slabby, horizontally stratified, poorly sorted, fine-grained, sublithic, micaceous .	20.5
11. Siltstone, sandy, grayish red (10R4/2), thin-bedded, nodular, horizontally stratified, poorly sorted; interbedded with sandstone, light brown (5YR6/4), thin-bedded, slabby, horizontally stratified, poorly sorted, medium-grained, lithic . . . . .	23.0	Total thickness of Lapoint Member . . . . .	401.5
10. Sandstone, silty, pale reddish brown (10R5/6), thin-bedded, slabby, horizontally stratified, poorly sorted, fine-grained, lithic . . . . .	34.5	Base of section; unit overlies moderate reddish brown (10R4/6) sandstone of Dry Gulch Creek Member.	
9. Claystone, sandy and silty, grayish red (10R4/2) and dark greenish gray (5GY4/1), very thin-bedded, nodular, laminated, poorly sorted; interbedded with sandstone, silty, moderate orange pink (5YR7/4), thin-bedded, slabby, horizontally			

### Starr Flat Member

Type section of Starr Flat Member; base of section south of John Starr Flat at an elevation of 6,500 feet at center of sec. 22, T. 1 N., R. 2 W. (Uinta Base Line), measured north-westward to the highest point on a prominent ridge at the boundary between secs. 34 and 35, T. 2 N., R. 3 W. (Uinta Base Line).

Top of section; unit overlain by unconsolidated terrace gravel.		horizontally stratified, poorly sorted, fine-grained, sublithic; interbedded with claystone, grayish red (5R5/2), very thin-bedded, nodular, laminated . . . . .	35.0
	Feet		
17. Sandstone, silty, with lenses of pebble conglomerate, moderate reddish brown (10R4/6) and pale reddish brown (10R5/4), very thick-bedded, massive, cross-stratified, poorly sorted, medium-grained, quartzose . . . . .	66.5	8. Sandstone, pale red (10R6/2), thick-bedded, blocky, structureless, poorly sorted, coarse-grained, quartzose; interbedded with claystone, pale red (5R6/2) and greenish gray (5GY5/1), very thin-bedded, platy, laminated . . . . .	35.0
16. Sandstone, dark reddish brown (10R3/6), thick-bedded, blocky, horizontally stratified, poorly sorted, coarse-grained, quartzose, micaceous . . . . .	40.0	7. Claystone, silty, grayish red (10R4/2) and pale olive (10Y6/2), very thin-bedded, platy, laminated, poorly sorted; interbedded with sandstone, silty, yellowish brown (10YR6/4), thin-bedded, friable, cross-stratified, poorly sorted, fine-grained, quartzose . . . . .	30.0
15. Sandstone, pebbly, moderate reddish brown (10R4/6), very thick-bedded, friable, cross-stratified, poorly sorted, very coarse-grained, quartzose . . . . .	51.0	6. Sandstone, dark yellowish orange (10YR6/6), thick-bedded, blocky, cross-stratified, poorly sorted, coarse-grained, sublithic; interbedded with siltstone, sandy, grayish red (10R4/2), thin-bedded, nodular, laminated, poorly sorted . . . . .	79.0
14. Sandstone, pebbly, moderate orange pink (5YR8/4), very thick-bedded, massive, horizontally stratified, poorly sorted, coarse-grained, quartzose; interbedded with sandstone, moderate reddish brown (10R4/6), thin-bedded, friable, horizontally stratified, poorly sorted, coarse-grained, quartzose, micaceous . . . . .	43.0	5. Sandstone, pale red (5R6/2), thick-bedded, blocky, horizontally stratified, poorly sorted, medium-grained, quartzose . . . . .	44.0
13. Sandstone, moderate reddish brown (10R4/6), very thick-bedded, massive, cross-stratified, poorly sorted, medium-grained, quartzose . . . . .	59.0	4. Claystone, silty, brownish gray (5YR4/1), very thin-bedded, platy, laminated; interbedded with siltstone, sandy, grayish red (5R4/2), thin-bedded, nodular, structureless, poorly sorted, quartzose; grades upward to sandstone, silty, pale red (10R6/2), thin-bedded, slabby, horizontally stratified, poorly sorted, very fine-grained, quartzose . . . . .	67.0
12. Sandstone, dark yellowish orange (10YR6/6), thin-bedded, slabby, structureless, moderately sorted, coarse-grained, sublithic; grades upward to sandstone, pale red (5R6/2) and yellowish brown (10YR6/4), very thick-bedded, massive, cross-stratified, poorly sorted, coarse-grained, sublithic, micaceous . . . . .	60.0	3. Sandstone and siltstone, sandy, pale red (5R6/2), thick-bedded, slabby, horizontally stratified, poorly sorted, medium-grained, quartzose . . . . .	20.5
11. Claystone, sandy, grayish red (10R4/2), very thin-bedded, nodular, structureless, poorly sorted; grades upward to sandstone, moderate yellowish brown (10YR5/4), thick-bedded, blocky, horizontally stratified, poorly sorted, coarse-grained, quartzose . . . . .	17.0	2. Sandstone, pebbly, moderate reddish brown (10R4/6), thick-bedded, massive, horizontally stratified, poorly sorted, coarse-grained, quartzose, erosion at base with low relief . . . . .	26.0
10. Sandstone, grayish red (10R5/2), thick-bedded, friable, lenticularly stratified, poorly sorted, coarse-grained, quartzose; interbedded with sandstone, clayey, light gray (N7), very thin-bedded, nodular, structureless, poorly sorted, very fine-grained, quartzose . . . . .	52.0	1. Sandstone, grayish orange (10YR7/4), thin-bedded, flaggy, laminated, poorly sorted, coarse-grained, lithic; interbedded with sandstone, silty, pale brown (5YR5/2), thin-bedded, nodular, structureless, poorly sorted, medium-grained, sublithic . . . . .	44.5
9. Sandstone, pale yellowish brown (10YR6/2), thin-bedded, slabby, structureless, poorly sorted, coarse-grained, sublithic; grades upward to sandstone, pale red (10R6/2), thick-bedded, blocky,		Total thickness of Starr Flat Member . . . . .	769.5
		Base of section; unit overlies light olive gray (5Y5/2) bentonitic claystone of Lapoint Member.	

# UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

103 Utah Geological Survey Building  
University of Utah  
Salt Lake City, Utah 84112

THE UTAH GEOLOGICAL AND MINERALOGICAL SURVEY since 1949 has been affiliated with the College of Mines and Mineral Industries at the University of Utah. It operates under a director with the advice and counsel of an Advisory Board appointed by the Board of Regents of the University of Utah from organizations and categories specified by law.

The survey is enjoined to cooperate with all existing agencies to the end that the geological and mineralogical resources of the state may be most advantageously investigated and publicized for the good of the state. The *Utah Code, Annotated, 1953 Replacement Volume 5, Chapter 36, 53-36-2*, describes the Survey's functions.

Official maps, bulletins, and circulars about Utah's resources are published. (Write to the Utah Geological and Mineralogical Survey for the latest list of publications available).

THE LIBRARY OF SAMPLES FOR GEOLOGIC RESEARCH. A modern library for stratigraphic sections, drill cores, well cuttings, and miscellaneous samples of geologic significance has been established by the Survey at the University of Utah. It was initiated by the Utah Geological and Mineralogical Survey in cooperation with the Departments of Geology of the universities in the state, the Utah Geological Society, and the Intermountain Association of Petroleum Geologists. This library was made possible in 1951 by a grant from the University of Utah Research Fund and by the donation of collections from various oil companies operating in Utah.

The objective is to collect, catalog, and systematically file geologically significant specimens for library reference, comparison, and research, particularly cuttings from all important wells driven in Utah, and from strategic wells in adjacent states, the formations, faunas, and structures of which have a direct bearing on the possibility of finding oil, gas, salines or other economically or geologically significant deposits in this state. For catalogs, facilities, hours, and service fees, contact the office of the Utah Geological and Mineralogical Survey.

THE SURVEY'S BASIC PHILOSOPHY is that of the U. S. Geological Survey, i.e., our employees shall have no interest in Utah lands. For permanent employees this restriction is lifted after a 2-year absence; for consultants employed on special problems, there is a similar time period which can be modified only after publication of the data or after the data have been acted upon. For consultants, there are no restrictions beyond the field of the problem, except where they are working on a broad area of the state and, here, as for all employees, we rely on their inherent integrity.

## DIRECTORS:

William P. Hewitt, 1961-

Arthur L. Crawford, 1949-1961