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LATE PALEOZOIC AND EARLY MESOZOIC STRATIGRAPHY OF UINTA MOUNTAINS, UTAH

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LATE PALEOZOIC AND EARLY MESOZOIC STRATIGRAPHY OF UINTA MOUNTAINS, UTAH[1]

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ABSTRACT

At the western end of the Uinta Mountains, Triassic rocks rest unconformably on the Permian Park City formation. From the base upward the Triassic rocks are (1) red Woodside shale, (2) marine Thaynes limestone, (3) Ankareh redbeds and (4) a conglomerate and overlying sandstones and shales. The Thaynes thins and tongues out eastward, and east of its edge the Woodside and the Ankareh can not be differentiated. The conglomerate, sandstones, and shales were classed as basal Nugget sandstone, Jurassic, by Boutwell (1912), but were excluded from the Nugget (Navajo sandstone) by Heaton (1939), leaving them without a name.

At the eastern end of the mountains, Woodside redbeds rest on the Pennsylvanian Weber sandstone. The lower part of the Woodside is the time equivalent of the upper Park City (Phosphoria). The Woodside is cut by an unconformity above which lies a conglomerate. The conglomerate was questionably classed as the basal member of the Ankareh by Sears (1926). The upper part of the Ankareh (?) of Sears consists of varicolored shales and sandstones and is directly overlain by the massive Navajo sandstone.

The conglomerate and the overlying varicolored beds are readily recognized from one end of the range to the other and constitute an unnamed lithologic unit which lies unconformably above the type Ankareh and below the restricted Nugget at the western end of the mountains, and unconformably above the Woodside and below the Navajo at the eastern end of the range. This unit is here named the Stanaker formation and the basal conglomerate, or grit, is named the Gartra grit member of the Stanaker formation. They are probably Upper Triassic in age.

The Jurassic formations of the western Uinta Mountains, from base upward are (1) Nugget sandstone, (2) Twin Creek limestone, (3) Preuss redbeds, (4) Stump sandstone, and (5) Morrison formation. Eastward along the mountains (1) the Nugget sandstone persists but is called Navajo on the east, (2) the Twin Creek limestone intertongues with the Carmel redbeds, (3) the Preuss redbeds grade into the cross-bedded Entrada sandstone, (4) the Stump sandstone grades into Curtis shales and limestones, and (5) the Morrison thins and becomes less conglomeratic. At the eastern end of the Uinta Mountains the Carmel redbeds thin out so that the Navajo is directly overlain by the Entrada, forming a single cross-bedded sandstone unit.

INTRODUCTION

Along the Uinta Mountains of northeastern Utah and northwestern Colorado there are striking east-west changes in the stratigraphy of the late Paleozoic and Mesozoic rocks. Because the range trends roughly at right angles to the ancient

[1] Manuscript received, March 31, 1946. Read in part before the Association at Denver, April 24, 1942. After the completion of this paper there came to the writers' attention an article entitled "Nomenclature of the Triassic Rocks of Northern Utah," by J. Stewart Williams, which appeared in the *American Journal of Science*, Vol. 234, No. 9 (September, 1945). The stratigraphic relations described in the three-page article by Williams are in close agreement with those herein described. The writers wish to note that they first described the relations of the Triassic rocks along the Uinta Mountains in a paper read at the twenty-seventh annual meeting of the American Association of Petroleum Geologists, Denver, April, 1942, and that an abstract was published in the program (pp. 38–39). In addition, early in 1942, a report prepared by Krueger for the Union Oil Company of California was placed in the office of the Indian Commissioner, Fort Duchesne, Utah. This report has been subject to public inspection. Williams refers to the use of the name "Ankareh grit" in unpublished reports. The report by Krueger used that terminology.

It is not the writers' intent to discuss the nomenclature proposed by Williams except to express their belief that the units they here name Stanaker formation and Gartra grit member are worthy of distinctive local names. The name, Red Wash, given by Williams, may be substituted for Woodside where the writers have used that name in sections in which the Thaynes limestone is not present.

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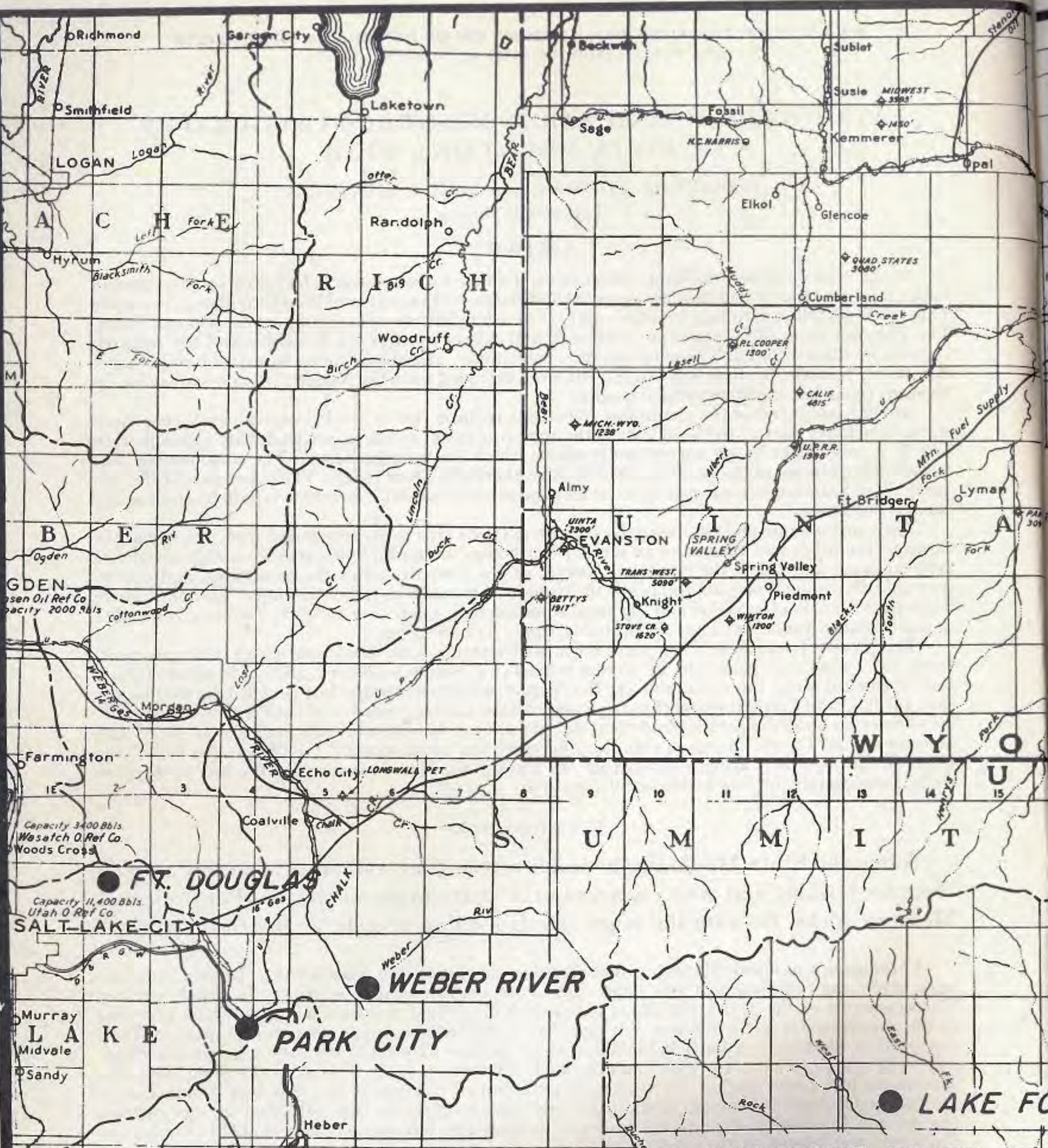
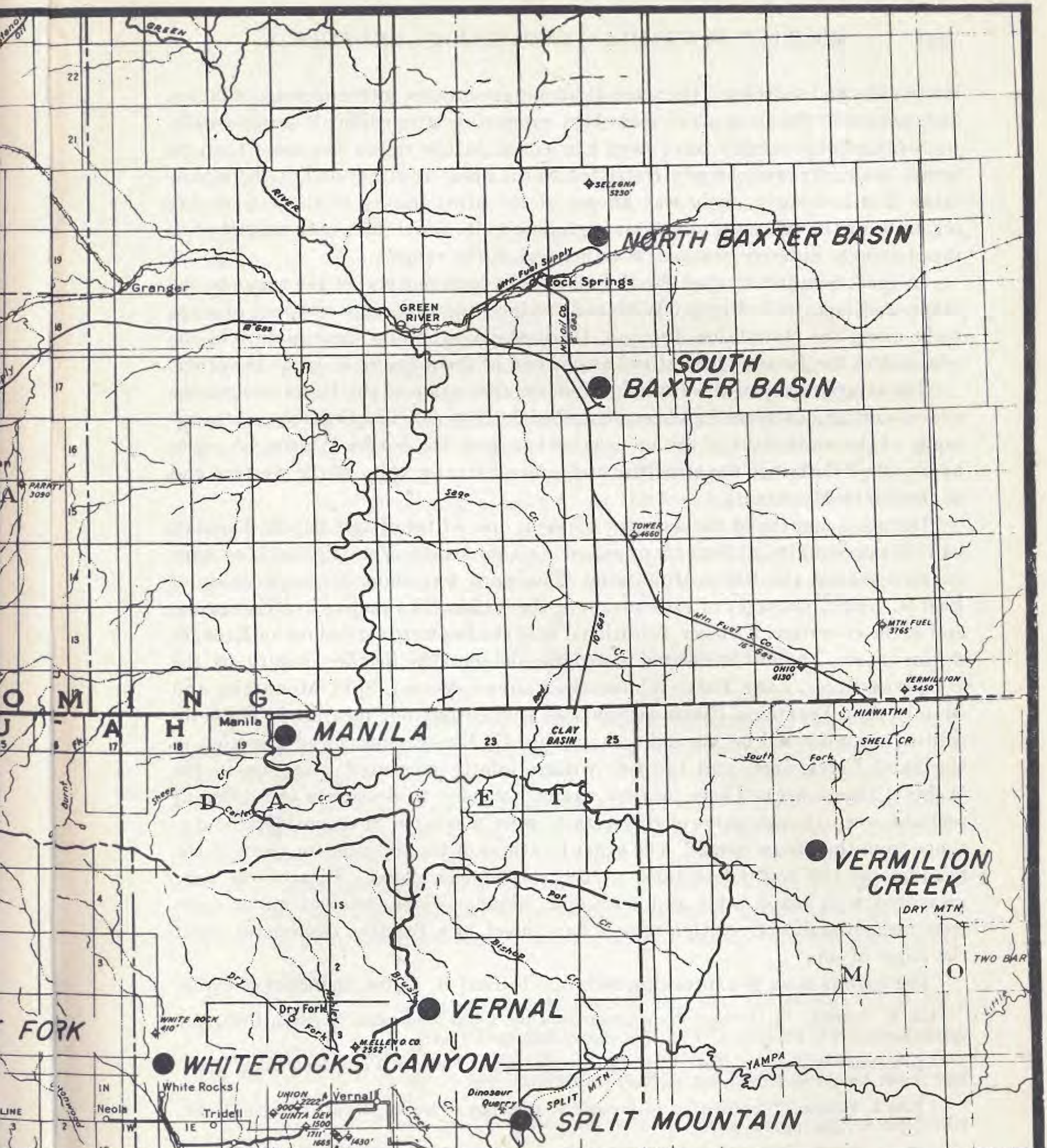


FIG. 1.—Index map showi



showinlocalities mentioned in text.

landmasses and shorelines, there are lithologic gradations, interfingerings of facies, and changes in thickness which make long-range correlation difficult or impossible.

Stratigraphic studies have been carried on in the region for more than 70 years, but oddly were largely restricted to the areas at either end of the mountains. Until recently, little was known of the stratigraphy of the intervening region or of the relations of the stratigraphic units which had been described in the strikingly different sections at either end of the range.

In 1918, Schultz[4] studied the Permian rocks from one end of the range to the other, and in 1939 J. Stewart Williams[5] clarified the east-west relations of these rocks along the mountains. In 1939, Heaton[6] gave the first clear picture of the relations of the Jurassic formations at one end of the range to those at the other.

The stratigraphy of the Jurassic Morrison formation of the Uinta Mountains and of contiguous areas has been described by Stokes.[7] The Cretaceous stratigraphy of the south flank of the mountains has been treated by Walton.[8] A paper by Eardley[9] describes the structure and general stratigraphy of the western end of the Uinta Mountains.

During 2 months of the summer of 1939, one writer of this paper, Thomas, had the opportunity to measure or examine all the strategic stratigraphic sections exposed around the Uinta Mountains. This work was under the supervision of Earl B. Noble, manager of exploration of the Union Oil Company of California, and of the co-writer, Krueger. Additional field studies were carried on by Krueger during 1940. Thomas measured stratigraphic sections in the vicinity of the Duchesne River, Lake Fork, Whiterocks Canyon, Vernal, Split Mountain, and Manila. The Vermilion Creek section was studied but not measured. These localities are indicated on the index map (Fig. 1). Krueger measured a section in the Skull Creek area, and the two writers jointly measured a section in the Weber Canyon area. These locality names are used to designate the different sections, even though parts of the sections were measured at a considerable distance from the places named. The exact locations of the sections are given in the headings of the written sections at the end of this paper. All sections were measured with plane table and telescopic alidade. Thicknesses of minor units were measured directly with a tape, a hand level, or a Brunton clinometer set at the angle of dip.

The writers wish to express appreciation to Earl B. Noble, manager of explo-

[4] A. R. Schultz, "A Geologic Reconnaissance of the Uinta Mountains, Northern Utah, with Special Reference to Phosphate," *U. S. Geol. Survey Bull. 690-C* (1918).

[5] J. Stewart Williams, " 'Park City' Beds on Southwest Flank of Uinta Mountains, Utah," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 1 (1939), pp. 82–100.

[6] Ross L. Heaton, "Contribution to Jurassic Stratigraphy of Rocky Mountain Region," *ibid.*, Vol. 23, No. 8 (1939), pp. 1153–77.

[7] W. L. Stokes, "Morrison and Related Deposits in and Adjacent to the Colorado Plateau," *Bull. Geol. Soc. America*, Vol. 55 (1944), pp. 951–92.

[8] Paul T. Walton, "Geology of the Cretaceous of the Uinta Basin, Utah," *ibid.*, pp. 91–130.

[9] A. J. Eardley, "Geology of the North-Central Wasatch Mountains, Utah," *ibid.*, pp. 819–94.

ration, and to the Union Oil Company of California for permission to publish this paper. James W. Vernon, a promising student in geology at the University of Wyoming who was killed in a fall from a cliff during the course of geological work later in 1939, served as instrument men for the stratigraphic measurements. Other geologists, all then of the Union Oil Company, who contributed to this work through field observations and by discussions are E. R. Atwill, R. W. Burns, J. C. Hazzard, C. F. Manlove, J. Q. Anderson, and W. C. Rauch. Their assistance is appreciated. In addition, the writers are indebted to J. B. Reeside, Jr., A. A. Baker, and J. D. Love of the United States Geological Survey for reading the manuscript and for offering comments and suggestions.

Over large areas along both flanks of the Uintas, the Paleozoic and Mesozoic rocks are covered by Tertiary beds. Younger glacial or fluviatile deposits constitute a mantle at many places. Well exposed sections, therefore, are found only at intervals along the range. The general regional geology is shown on an older map by Schultz[10] and on more recent maps by Forrester[11] and Walton.[12]

The relations of the Triassic rocks along the mountains are here presented for the first time and this paper, therefore, describes the stratigraphy of the interval between the Permian rocks below, described by Williams, and the Jurassic rocks above, described by Heaton. In addition, new information is given on Permian and Jurassic stratigraphy.

EVOLUTION OF STRATIGRAPHIC NOMENCLATURE

WESTERN UINTA MOUNTAINS

The details of the stratigraphy of the Park City district, at the western end of the Uinta Mountains, were first described by Boutwell in 1907[13] (Fig. 2). The name, Weber, applied by King[14] in 1876 to a thick sandstone along the Weber River, north of the Park City district, was carried south by Boutwell and applied to the oldest unit exposed in the Park City district. The Weber is classed as Pennsylvanian in age and has been described recently by Williams.[15] To limestones and other beds lying directly above the Weber, Boutwell applied the new name, Park City. The Park City is classed as Permian in age and the upper part is correlated with the Phosphoria formation.[16] The name, Woodside, was given

[10] A. R. Schultz, *op. cit.*

[11] J. D. Forrester, "Structure of the Uinta Mountains," *Bull. Geol. Soc. America*, Vol. 48, No. 5 (1937), Pl. 3.

[12] Paul T. Walton, *op. cit.*, Pl. 2.

[13] J. M. Boutwell, "Stratigraphy and Structure of the Park City Mining District, Utah," *Jour. Geol.*, Vol. 15 (1907), pp. 434–58.

[14] Clarence King, "Paleozoic Subdivisions on the Fortieth Parallel," *Amer. Jour. Sci.*, 3d Ser., Vol. 11 (1876), pp. 477–79.

[15] J. Stewart Williams, "Carboniferous Formations of the Uinta and Northern Wasatch Mountains, Utah," *Bull. Geol. Soc. America*, Vol. 54, No. 4 (1943), pp. 591–624.

[16] A. A. Baker and J. Steele Williams, "Permian in Parts of Rocky Mountain and Colorado Plateau Regions," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 24, No. 4 (1940), pp. 716–35.

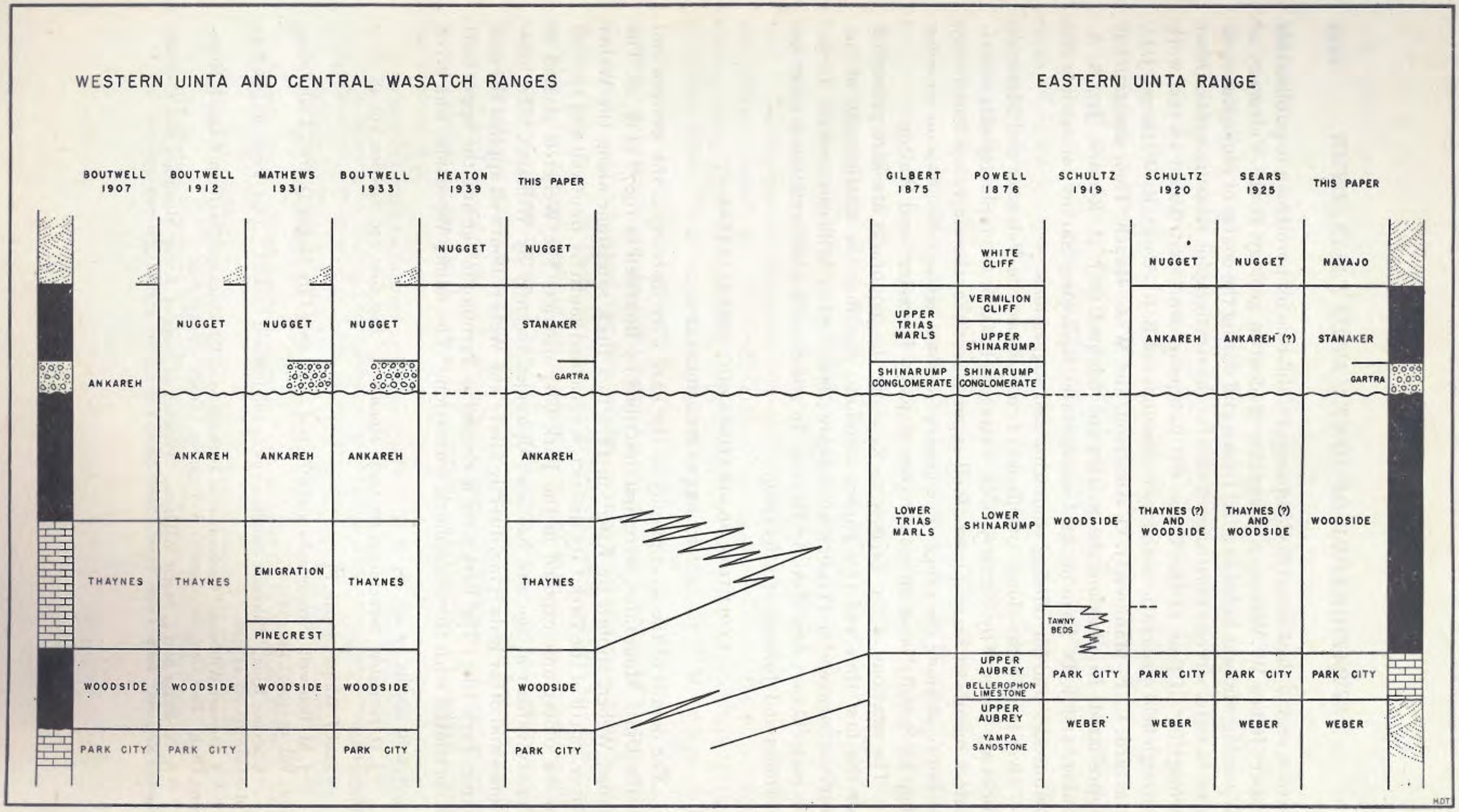


FIG. 2.—Evolution of stratigraphic nomenclature of late Paleozoic and early Mesozoic rocks of Uinta Mountains.

by Boutwell to 700 feet of "fine-grained dark-red shale" overlying the Park City. The next higher formation was named Thaynes limestone by Boutwell. He described the Thaynes as consisting of a lower 445-foot unit made up of fossiliferous limestones, calcareous and other sandstones, and red and gray shale; a middle 115-foot red shale unit; and an upper 630-foot unit lithologically similar to the basal unit. He pointed out that no unconformity was observed below or above the Thaynes. The highest beds exposed in the district were included in the Ankareh formation, named by Boutwell. As described, the Ankareh consisted of more than 1,500 feet of red shales, which in places are sandy, with a number of beds of rather coarse sandstone from 20 to 55 feet thick.

The division between the Thaynes and the Ankareh was based on lithology, the Thaynes being characterized by calcareous beds and the Ankareh by red shales and sandstones. A sandstone lying "at the base of the red shale as a whole and immediately below a thin limestone" was taken arbitrarily as the base of the Ankareh, and typical Thaynes fossils were reported from the basal 200 feet of the Ankareh. Boutwell mentioned a main sandstone member at the top of the Ankareh and the occurrence of petrified wood just below it. The Woodside, Thaynes, and lower Ankareh were classed as Permian; the age of the upper Ankareh was left open to question.

In 1912, Boutwell[17] further described the stratigraphy of the Park City district. Few changes were made other than age assignments. The Woodside, Thaynes, and lower Ankareh were classed as Lower Triassic and the age of the upper Ankareh was again left open to question. The major change made was to bring the name, Nugget, into the region, that name having been applied by Veatch, in 1907, to a sandstone in southwestern Wyoming.[18] The original Nugget of Veatch comprised a lower redbeds part, just above the Thaynes, and an upper thick sandstone part. In 1910,[19] the name, Nugget, had been restricted to the sandstone unit, and Boutwell pointed out that at the top of his original Ankareh were white sandstones with some intercalated reddish shales which he thought represented the lower part of the restricted Nugget.

In 1931, Mathews[20] described the Mesozoic rocks of the Wasatch Mountains in the area northwest of the Park City district. The Thaynes was divided into the Pinecrest formation, below, and the Emigration formation, above. The overlying Ankareh, according to Mathews, is unlike the type Ankareh in that instead of being mainly siliceous sandstone, it is an ox-blood red fine-grained shale with

[17] J. M. Boutwell, "Geology and Ore Deposits of the Park City District, Utah," *U. S. Geol. Survey Prof. Paper 77* (1912).

[18] A. C. Veatch, "Geology and Geography of a Portion of Southwestern Wyoming, with Special Reference to Coal and Oil," *U. S. Geol. Survey Prof. Paper 56* (1907).

[19] H. S. Gale and R. W. Richards, "Preliminary Report on the Phosphate Deposits in South eastern Idaho and Adjacent Parts of Wyoming and Utah," *U. S. Geol. Survey Bull. 430* (1910), pp. 457–535.

[20] A. A. L. Mathews, "Mesozoic Stratigraphy of the Central Wasatch Mountains," *Oberlin College Lab. Bull.*, New Ser., No. 1 (1931).

only thin beds of sandstone. It was implied that the thickness is 450 feet. The Nugget, as differentiated by Mathews, comprised a basal conglomerate, fine- and coarse-grained sandstones, intercalated gypsiferous dark red to pale blue shales and some limestones, and a characteristic creamy white or yellowish white sandstone at the top of the formation. The basal conglomerate, 48 feet thick in one place, rests above an unconformity.

In 1933, Boutwell[21] further described these formations. In the Park City district he recognized Woodside redbeds at the base; Thaynes limestone; Ankareh bright red shale and sandstone and a few thin limestones; and Nugget, described as a "massive coarse-grained grayish-white cross-bedded sandstone carrying no fauna but some petrified wood." He described the Nugget of the Cottonwood district as a "gray sandstone with a basal conglomerate overlying the Ankareh, together with associated red shale members."[22]

In 1939, Heaton[23] substituted the name Navajo for Nugget and placed the base of the Navajo of the western Uinta Mountains at the base of the massive sandstone unit, excluding the subjacent redbeds and conglomerate. It becomes apparent, therefore, that both Boutwell's and Mathews' concept of the sequence was as follows.

Nugget	Thick sandstone unit Redbeds with petrified wood Basal conglomerate
Unconformity	
Ankareh	Redbeds
Thaynes	Limestones *et cetera*
Woodside	Redbeds
Park City	Limestones *et cetera*

The important point made here is that both considered the conglomerate and the redbeds with petrified wood to be basal units of the Nugget. As shown later, these two units constitute the so-called Ankareh at the eastern end of the mountains.

EASTERN UINTA MOUNTAINS

As early as 1875, Gilbert[24] divided the redbeds of the eastern Uinta Mountains into (1) †Lower Trias marls at the base, (2) Shinarump conglomerate, and (3) †Upper Trias marls above.*

In 1876, Powell[25] described the stratigraphic sequence along the Green River.

[21] J. M. Boutwell, "The Salt Lake Region," *Sixteenth Internat. Geol. Cong., U. S., Guidebook 17* (1933), pp. 73–74.

[22] *Ibid.*, p. 86.

[23] Ross L. Heaton, *op. cit.*

[24] G. K. Gilbert, "Report on the Geology of Portions of Nevada, Utah, California and Arizona," *U. S. Geol. and Geog. Survey W. 100th Meridian* (Wheeler), Vol. 3 (1875), pp. 17–187.

* Stratigraphic names which have been abandoned or have become obsolete are indicated by a dagger preceding the term.

[25] J. W. Powell, "Geology of the Eastern Portion of the Uinta Mountains," *U. S. Geol. and Geog. Survey Terr.* (Powell) (1876).

A thick sandstone, the Weber of current nomenclature, was named the †Yampa sandstone. The overlying unit of phosphatic shale, limestone and chert, now recognized as Park City, was called the †Bellerophon limestone. The redbeds next above were called †Shinarump group and divided into †Lower Shinarump, Shinarump conglomerate, and †Upper Shinarump. Powell said, "The conglomerate which is found in the middle of the group is persistent over a very large area . . ." (p. 69) and "The variegated beds above . . . the conglomerate are seen in many places on either flank of the Uinta Mountains . . . " (p. 54).

Powell differentiated certain beds above the †Shinarump group as the †Vermilion Cliff group but it is difficult to determine the boundary in the field to-day. He gave the name †White Cliff group to the light-colored cross-bedded sandstone above the †Vermilion Cliff group. This is the Navajo or Nugget sandstone of current nomenclature.

In 1919, Schultz,[26] studying the phosphate deposits, applied the name, Weber, to Powell's †Yampa sandstone and carried the term, Park City formation, into the eastern Uinta Mountains. In places he included tawny beds in the top of the Park City, but there are no such beds in the upper part of the type Park City. The redbeds just above were classed as Woodside formation.

Later, in 1920, Schultz,[27] on a chart, classed the main body of redbeds above the Park City as "Woodside and Thaynes (?)." An unconformity was shown above this unit and the name, Ankareh, was applied to the 300 feet of beds between the unconformity and the Nugget sandstone.

In 1925, Sears[28] gave a detailed section measured on Vermilion Creek. The nomenclature of Schultz, 1920, was used except for questioning the name, Ankareh. The "Ankareh (?)" of Sears comprised a basal conglomerate and overlying varicolored beds.

Workers in the eastern Uinta Mountains, therefore, have applied the name, Ankareh, to a conglomerate and varicolored beds which can be shown to lie above the type Ankareh and were included in the Nugget sandstone by workers in the western Uinta Mountains. The conglomerate and overlying varicolored beds constitute important units in the stratigraphy of the Uinta Mountains and have never been properly named.

PERMIAN STRATIGRAPHY

Park City formation.—The Park City formation of the Uinta Mountains, originally described by Boutwell,[29] has been discussed recently by A. A. Baker

[26] A. R. Schultz, *op. cit.*

[27] A. R. Schultz, "Oil Possibilities in and around Baxter Basin, in the Rock Springs Uplift, Sweetwater County, Wyoming," *U. S. Geol. Survey Bull. 702* (1920), p. 36.

[28] J. D. Sears, "Geology and Oil and Gas Prospects of Part of Moffat County, Colorado, and Southern Sweetwater County, Wyoming," *U. S. Geol. Survey Bull. 751-G* (1924), pp. 280–81.

[29] J. M. Boutwell, "Stratigraphy and Structure of the Park City Mining District, Utah," *Jour. Geol.*, Vol. 15 (1907), pp. 439–58.

and J. Steele Williams,[30] and by J. Stewart Williams.[31,32] Baker and Williams discussed the relation of the type Park City to the type Phosphoria of Idaho and showed that the upper cherty limestone unit and the subjacent phosphatic shale unit of the type Park City correspond with the Phosphoria. Even though the phosphatic shale unit of the Park City rests directly on the Weber sandstone in places along the Uinta Range (Fig. 3) and the beds there could conceivably be called Phosphoria formation, the writers have preferred to use the name, Park City, throughout the area since in few places do the beds of Phosphoria lithology have the exact time scope of the type Phosphoria.

J. Stewart Williams[33] described the interfingering of the Park City with redbeds along the south flank of the mountains. The writers remeasured or examined all

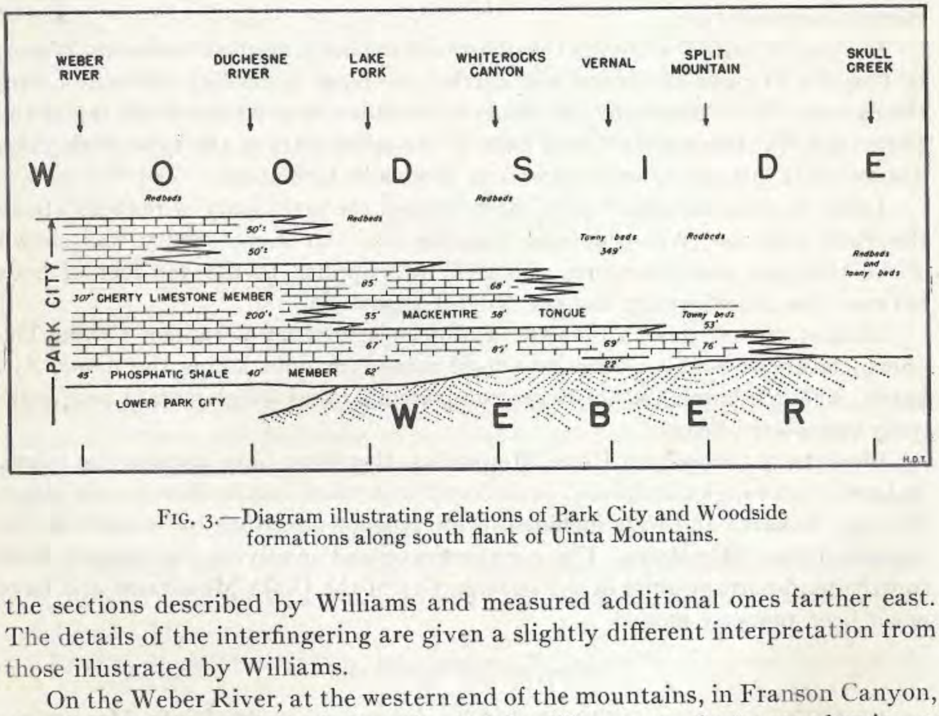


FIG. 3.—Diagram illustrating relations of Park City and Woodside formations along south flank of Uinta Mountains.

the sections described by Williams and measured additional ones farther east. The details of the interfingering are given a slightly different interpretation from those illustrated by Williams.

On the Weber River, at the western end of the mountains, in Franson Canyon, the Park City has a typical tripartite division. The upper cherty member is 307 feet thick and overlies the phosphatic shale member, which is 45 feet thick. The

[30] A. A. Baker and J. Steele Williams, *op. cit.*, pp. 627–29.

[31] J. Stewart Williams, " 'Park City' beds on Southwest Flank of Uinta Mountains, Utah," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 1 (1939), pp. 82–100.

[32] ———, "Carboniferous Formations of the Uinta, and Northern Wasatch Mountains, Utah," *Bull. Geol. Soc. America*, Vol. 54, No. 4 (1943), pp. 617–19.

[33] J. Stewart Williams, " 'Park City' Beds on Southwest Flank of Uinta Mountains, Utah," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 1 (1939), pp. 82–100.

part of the Park City below the phosphatic shale was not studied in detail, but lithologically it is similar to parts of the Phosphoria of Idaho and Wyoming, and the few fossils collected, comprising *Schizodus* sp., *Orbiculoidea utahensis*, and shark denticles like those in the Phosphoria of central Wyoming, suggest a close relation to the part of the formation above the phosphatic shale.

The phosphatic shale persists as a unit eastward from Franson Canyon along the south flank of the mountains. In the central part it rests directly on the Weber sandstone and the lower Park City is missing. Near Vernal, the eastern-

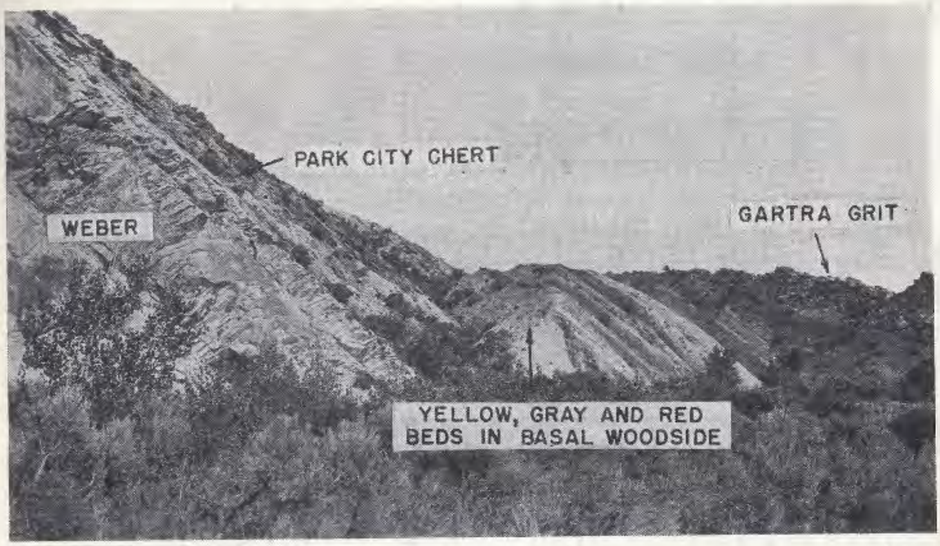


FIG. 4.—Thin Park City chert resting on Weber sandstone at Split Mountain. Yellow, gray and red beds in the basal Woodside are Park City in age.

most section in which phosphatic shale was seen, it is 22 feet thick, but at Split Mountain the member could not be recognized and the basal Park City there has assumed a cherty nature (Fig. 4).

The upper Park City cherty member, east of Franson Canyon, is penetrated from the east by tongues of redbeds which are evident in sections along the Duchesene River, Lake Fork, and at Whiterocks Canyon. The cherty member is partly replaced by redbeds at Lake Fork, but a cherty limestone tongue extends eastward and forms the upper unit of the Park City at Lake Fork and at Whiterocks Canyon. This unit is completely replaced by redbeds between Whiterocks Canyon and the next exposures eastward, near Vernal. A red shale tongue, named the Mackentire tongue by Williams,[34] is recognizable in the Lake Fork and Whiterocks Canyon sections, but east of the edge of the overlying cherty

[34] *Ibid.*, pp. 91–92.

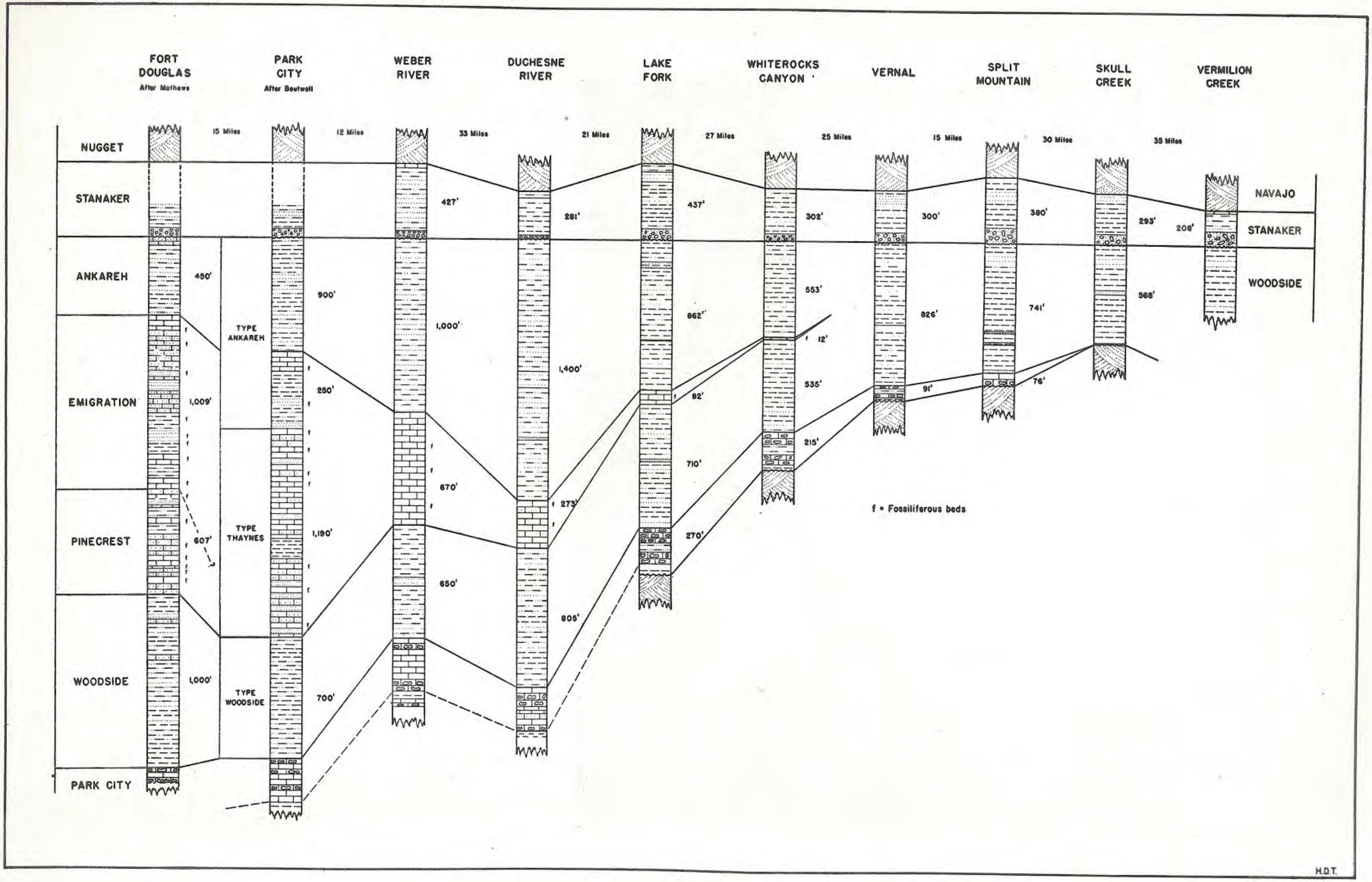


FIG. [illegible]. Correlation of Triassic rocks along south flank of Uinta Mountains tongue, as near Vernal, can not be separated from the Woodside. The basal part of the upper Park City cherty member extends eastward as far as Split Mouhtain, but at Skull Creek, the easternmost section studied, has been replaced by red or tawny shale. At Skull Creek, the basal part of the Woodside is the time-equivalent of the upper Park City cherty member of sections on the west. This interfingering with and replacement by redbeds is similar to that in Wyoming where the Phosphoria of sections in central Wyoming is represented in the basal Chugwater redbeds in southeastern Wyoming.[35]

TRIASSIC STRATIGRAPHY

GENERAL RELATIONS OF FORMATIONS

In the western part of the Uinta Mountains the older Triassic formations comprise the Woodside redbeds at the base, the marine Thaynes limestone in the middle, and the Ankareh redbeds, as restricted by Boutwell (Fig. 5) at the top. The restricted Ankareh is overlain unconformably by a set of younger Triassic beds which comprise a conspicuous basal conglomerate, or grit, which Boutwell considered to be the basal unit of the Nugget sandstone, and an overlying variable sequence of lavender, red, maroon, ocher and green shales, reddish and tannish sandstones, silty sandstones, and sandy siltstones, with less common limestones or calcareous shales. These varicolored beds are overlain by the thick distinctive Nugget (Navajo) sandstone.

To the eastward, the major changes in the older Triassic formations are (1) a general thinning, and (2) the wedging-out of the Thaynes limestone. The wedging-out of the Thaynes brings the lower redbeds (Woodside) into contact with the upper redbeds (Ankareh) and there is no apparent demarcation between rocks representing the two units.

The grit and overlying varicolored beds which unconformably overlie the type Ankareh along the western part of the mountains persist eastward with but little change and are conspicuous at the eastern end of the range, where they have been called Ankareh (?) formation. These beds are here given the name Stanaker formation, and the basal conglomerate designated as the Gartra grit member. Their stratigraphic details are discussed fully later in this paper.

EARLIER TRIASSIC STRATIGRAPHY

Nomenclatural problems.—It is unfortunate, perhaps, that Boutwell divided the older Triassic rocks into three formations, since away from the type locality the lower redbeds (Woodside) can be separated from the upper redbeds (Ankareh) only where the Thaynes limestone is present. East of the wedge-edge of the Thaynes, the single redbeds unit might be referred to as "Woodside-Ankareh," but the use of such hypenated names is not in accord with the best principles of

[35] Horace D. Thomas, "Phosphoria and Dinwoody Tongues in lower Chugwater of Central and Southeastern Wyoming," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 18, No. 12 (1934), pp. 1655–97.

stratigraphic nomenclature. It would be best to apply a group name to include Woodside, Thaynes, and Ankareh which could be used as a formation name where the Thaynes limestone is absent. This would involve the application of a new name which would have to be substituted for the name, Woodside, as it is now used in many places. Such a revision made now might not be entirely workable later. For instance, the Woodside thins strikingly between Vernal and Skull Creek (Fig. 5) and this thinning is known to continue southward and southeastward. In the thin sections the Woodside is probably equivalent only to type Woodside, with no Ankareh equivalent present. The writers prefer to postpone any revision of the nomenclature until the time when additional detailed information is available on the stratigraphy of the older Triassic rocks over a greater area than that considered in this paper and until regional relationships are better understood. Until that time it seems best in the Uinta Mountains region to use the names, Woodside, Thaynes, and Ankareh, in a formational sense over the area where all three are present, and to use the name, Woodside, as has been done, over the area in which the Thaynes is lacking, taking recognition of the fact that in some places beds as young as Ankareh may be included in the upper part of the Woodside.

Woodside shale.—Along the western part of the Uinta Mountains, the Woodside consists of 500 to 800 feet of red to maroon shales, siltstones, and very fine-grained sandstones, the monotony of color being broken rarely by thin gray or greenish siltstones or sandstones. Along the eastern part of the mountains, however, the red color of the formation gives way to considerable thicknesses of tawny, tan, or olive-drab beds. No traces of fossils were found in any part of the Woodside on the south flank of the Mountains.

In western Wyoming the Phosphoria is overlain disconformably by the Dinwoody formation, which has been dated by Newell and Kummel[36] as early Lower Triassic in age. The type Woodside rests directly above the Phosphoria equivalent of the Park City, and it is likely that the lower Woodside is a redbeds facies of the same age as the Dinwoody. Eastward, along the Uinta Mountains, however, it is impossible to separate redbeds of Park City age from the true Woodside, and the base of the Woodside descends in the section until at Skull Creek the entire upper Park City is represented by the basal Woodside. The red Chugwater and Spearfish shales of eastern Wyoming are similarly made up of Permian and Triassic parts which can not be separated at the present time.

Near Vernal the lower part of the Woodside is characterized by tawny beds which rest on the thin basal chert of the Park City and are 350 feet thick. They were classed as the upper part of the Park City by Schultz,[37] although he pointed out their similarity to the Dinwoody formation of Wyoming. The tawny beds

[36] Norman D. Newell and Bernhard Kummel, "Lower Eo-Triassic Stratigraphy of Western Wyoming and Southeast Idaho," *Bull. Geol. Soc. America*, Vol. 53 (1942), pp. 937–96.

[37] A. R. Schultz, "A Geological Reconnaissance of the Uinta Mountains, Northern Utah, with Special Reference to Phosphate," *U. S. Geol. Survey Bull. 690-C* (1918), p. 54.

near Vernal, however, differ from the type Dinwoody in that the lower part is Permian in age. At Manila, on the north flank of the Uinta Mountains, the Park City is overlain by 740 feet of tawny beds, and the entire Woodside at Vermilion Creek, at the eastern end of the mountains, has a tawny color.[38] Gilluly has shown that the Moenkopi of the San Raphael Swell, whose lower part is the probable equivalent of the Woodside, varies from redbeds to tawny beds, that there is a gradation between the two lithologic types, and that the tawny beds were probably deposited in a somewhat different environment from the redbeds.[39]

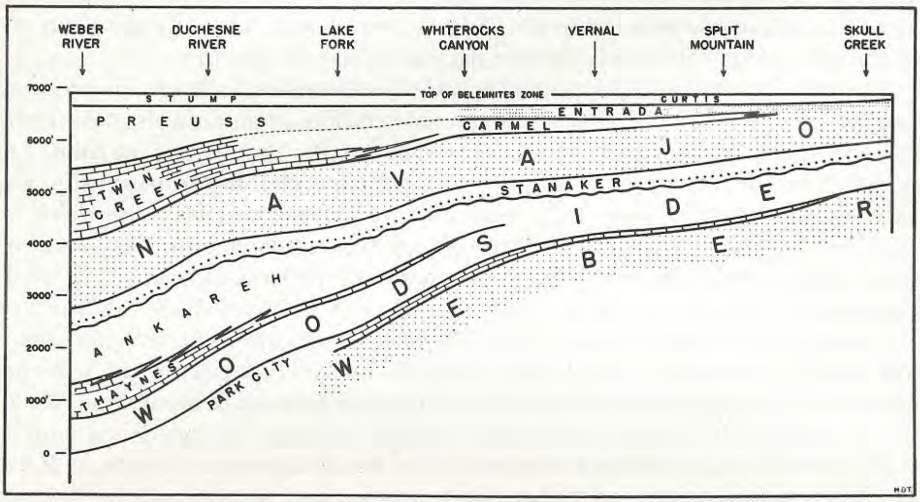


FIG. 6.—Stratigraphic diagram showing relations of Permian, Triassic, and Jurassic formations along south flank of Uinta Mountains.

Although tawny beds are conspicuous in the eastern part of the Uinta Mountains they do not constitute a definite unit. They are partly Park City in age and partly Woodside in age and should be included with the Woodside rather than described as a distinct stratigraphic unit.

The eastward thinning of the Woodside in the area where it is overlain by Thaynes limestone is probably attributable to more rapid sedimentation on the west than on the east during the same span of geologic time. The thinning of the Woodside and Ankareh, where the two units are not separated by Thaynes limestone, as in the area between Vernal and Skull Creek, is apparently related to the unconformity at the base of the Gartra grit. It is suggested that the Woodside at Skull Creek probably represents rocks nearly equivalent to the type Woodside,

[38] J. D. Sears, *op. cit.*, p. 281.

[39] James Gilluly, "Geology and Oil and Gas Prospects of Part of the San Raphael Swell, Utah," *U. S. Geol. Survey Bull. 806-C* (1929), p. 86.

and that beds of post-Woodside age were largely removed by erosion prior to the deposition of the Gartra grit (Fig. 6).

Thaynes limestone.—The Thaynes limestone at the western end of the mountains is made up of gray to brown thick-bedded to thin-bedded limestones, sandy limestones, and calcareous sandstones. Certain parts are very fossiliferous, but no attempt was made by the writers to obtain complete faunal collections for study. The Thaynes is, however, obviously a normal marine deposit. As the Thaynes thins eastward it becomes a white very fine-grained sandy limestone in beds ranging from one to two feet in thickness. In the vicinity of Deep Creek, between Whiterocks Canyon and Vernal, the Thaynes has thinned to less than 2 feet, but still contains a few fossils. East of Deep Creek it is not identifiable, although some thin calcareous laminae persist for a short distance.

Ankareh formation.—The Ankareh, like the Woodside, is made up predominantly of red to maroon shales, siltstones and very fine-grained sandstones. There may be intercalated beds of coarser sandstone, either gray or red in color, but these do not form an appreciable part of any section. A thin bed of gypsum was noted in the Ankareh along Lake Fork, but no gypsum was seen elsewhere.

There is some indication that there is a gradation between the Thaynes limestone and the Ankareh, with limestone replaced by redbeds eastward (Fig. 6). It is suggested that the redbeds thicken eastward between Weber River and Duchesne River at the expense of the Thaynes, which thins. The fact that Boutwell reported marine fossils in calcareous beds in the lower part of the sequence he classed as Ankareh,[40] and that the dividing line between Thaynes and Woodside was arbitrarily placed at the point of major lithologic change, lends support to this concept. The eastward thinning of the Ankareh between Duchesne River and Whiterocks Canyon is attributable to erosion and beveling of the Ankareh prior to the deposition of the Gartra grit.

LATER TRIASSIC STRATIGRAPHY

General considerations.—It has been pointed out that the conglomerate and varicolored beds which at the west end of the Uinta Mountains were included by Boutwell in the base of the Nugget and which at the east end of the mountains were called Ankareh (?) by Schultz, constitute important stratigraphic units which are without names. It is the object here to apply new names and to describe the regional stratigraphy of the units.

It would be possible to bring in formation names from elsewhere and apply them to the rocks in question, but if new names are given there is no chance for an error in correlation and, in addition, the names will be distinctive of the Uinta Mountain region.

As frequently happens in selecting names for stratigraphic units in the West, the writers were hard-pressed to find suitable geographic names near best ex-

[40] J. M. Boutwell, "Geology and Ore Deposits of the Park City District, Utah," *U.S. Geol. Survey Prof. Paper 77* (1912), pp. 58–59 and Pl. 5.

posures of the units to be named. Article 7, Remark b, of the "Classification and Nomenclature of Rock Units,"[41] points out that the type section of a stratigraphic unit need not be located exactly at the geographic point from which the name is derived, though it should not be far removed. Because of the scarcity of acceptable geographic names in the area about the type section, the writers have found it necessary to go rather far afield in order to find desirable names.

Stanaker formation (*new name*)*—The name, Stanaker formation, is here applied to the basal conglomerate and overlying varicolored shales and sandstones which were included in the Nugget by Boutwell and classed as Ankareh (?) by Sears. To the basal conglomerate the name Gartra grit member of the Stanaker formation (new name) is here applied. The name, Stanaker, is derived from Stanaker Draw which lies in the eastern part of T. 3 S., R. 21 E., Uintah County, Utah, and is shown on the United States Geological Survey topographic sheet of the Marsh Peak Quadrangle.[42] The name, Gartra, is taken from Gartra Spring, located in Sec. 11, T. 2 S., R. 21 E., as shown on the United States Forest Service map of the Ashley National Forest.

The type section of the Stanaker formation and of the Gartra grit member, however, is located at the point where the Vernal-Manila highway crosses Brush Creek, about 10 miles north of Vernal, in the north part of Sec. 5, T. 3 S., R. 22 E. The stratigraphic section, here given as the type section (see p. 1289), was measured immediately south of Brush Creek, where the Gartra grit forms a cliff just south of a ranch a few hundred feet west of the Vernal-Manila highway and where the upper part of the formation is exposed along the highway just south of Brush Creek.

At the type section the Gartra grit rests unconformably on a surface exhibiting considerable relief cut on the Woodside shale (Fig. 7). There is a sharp lithologic change from Woodside redbeds below the erosion surface to gray cross-bedded grit above. A similar relationship is shown in all exposures around the Uinta Mountains. Because of the irregular nature of the basal contact, the Gartra grit ranges in thickness from 40 to 80 feet near the type section.

Everywhere along the south flank of the Uinta Mountains, from Weber River to Skull Creek, and at Vermilion Creek, the Gartra grit is gray poorly sorted coarse-grained feldspathic quartz grit with sporadic quartz pebbles as large as one inch in diameter. In places the coarser grit and pebble beds seem to be lenticular in nature. The poorly sorted character of the grit causes marked changes in texture both laterally and vertically, but in general the bed is coarser in texture near the base than near the top.

[41] G. H. Ashley *et al.*, "Classification and Nomenclature of Rock Units," *Bull. Geol. Soc. America*, Vol. 44 (1933), p. 433.

* The names Stanaker and Gartra have not been used previously in stratigraphic nomenclature and are, therefore, available as new names.—Personal communication, H. D. Miser, United States Geological Survey, May, 1946.

[42] On the United States Forest Service map of the Ashley National Forest, the name is spelled Steinaker, but the older spelling is preferred by the writers.

The upper contact of the grit is sharp and the bed is in most places directly overlain by shale. In places, as in the type section, there are thin grit beds lithologically like the main grit body, but not as coarse-grained, interbedded in the shales just above the Gartra. Whether or not there are thin grit beds above the Gartra grit member in other sections can not be determined because of poor exposures.

Variations in thickness of the Gartra grit are as follows: Weber River, 33 feet; Duchesne River, 26 feet; Lake Fork, 67 feet; Whiterocks Canyon, 43 feet; Split

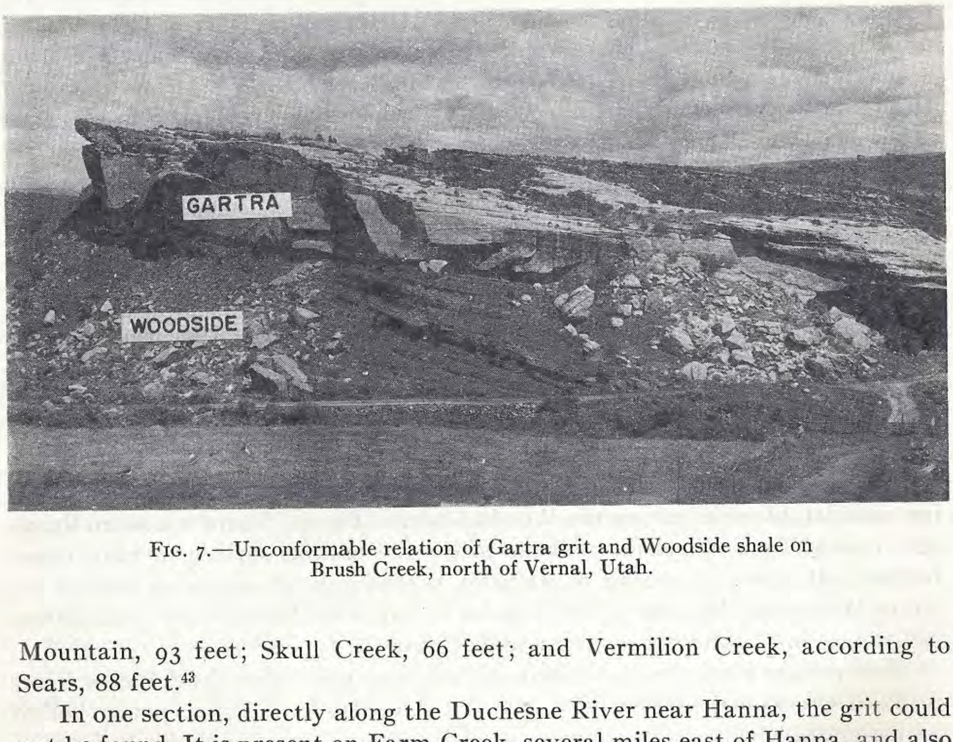


FIG. 7.—Unconformable relation of Gartra grit and Woodside shale on Brush Creek, north of Vernal, Utah.

Mountain, 93 feet; Skull Creek, 66 feet; and Vermilion Creek, according to Sears, 88 feet.[43]

In one section, directly along the Duchesne River near Hanna, the grit could not be found. It is present on Farm Creek, several miles east of Hanna, and also at the west in the Park City district, on the Weber River, and, according to Mathews,[44] at many places in the Wasatch Mountains. Since the bed presents all the characters of a fluviatile deposit, it would not be unexpected for it to thin out in places; however, it may be covered or faulted out along the Duchesne River.

At Manila, on the north flank of the mountains, the Gartra differs strikingly in lithologic character from the occurrences on the south flank of the mountains.

[43] J. D. Sears, *op. cit.*, p. 280.

[44] A. A. L. Mathews, *op. cit.*, pp. 41–42.

There it consists of lenses of purplish red limestone pebble conglomerate set in a matrix of purplish red cross-bedded coarse-grained sandstone. The bed has a sharp contact with the subjacent Woodside and lithologically is strikingly dissimilar to the underlying red siltstones. The thickness is 18 feet. Higher in the section, however, and separated from the limestone pebble conglomerate by 120 feet of shales, is a 3-foot bed of very coarse-grained quartz granule grit which is lithologically like the grit on the south flank of the mountains.

The part of the Stanaker formation lying above the Gartra grit member is made up of varicolored shales and sandstones which are sharply overlain by the massive Nugget or Navajo sandstone. Lying between two resistant units, these softer beds are generally not well exposed. The main body of the Stanaker formation comprises an alternation of shales which vary in color from maroon to red, pink, lavender, ocher, and green, and of sandstones which are gray, red, purple, or yellow in color. The different colors in any one section seem fairly well confined to certain beds. Limestones are not conspicuous, but in the Weber River section there is a pink and gray platy thin-bedded ribbon limestone near the top of the formation, and some sandstones in other sections are calcareous.

The only fossils found in the formation were fragments of silicified wood. Boutwell mentioned the occurrence of petrified wood in beds he classed with the Nugget sandstone,[45] but which probably represent the Stanaker formation.

The thickness of the upper part of the Stanaker, exclusive of the Gartra grit, is as follows: Weber River, 394 feet; Duchesne River, 255 feet; Lake Fork, 370 feet; Whiterocks Canyon, 259 feet; Brush Creek (type section) 240 feet; Split Mountain, 287 feet; Skull Creek, 227 feet; Manila, 284 feet; and Vermilion Creek, 120 feet, according to Sears.[46]

The feldspathic nature of the Gartra grit implies that it was derived from a granitic terrane. It is quite possible that the source of the grit was the granite of the Uncompahgre positive area of central-western Colorado, about 125 miles southeast of the eastern end of the Uinta Mountains. This uplift was a positive area well into Jurassic time.[47] The limestone pebble conglomerate of the Manila area apparently had a different source, although later some grit was carried that far northward. This limestone pebble conglomerate is lithologically like the Jelm conglomerate which occurs along the Sierra Madre and Medicine Bow Mountains of southeastern Wyoming, east of the Uinta Mountains.

Age and correlation.—The writers have no paleontologic evidence which might determine the age of the Stanaker formation, but on the basis of regional rela-

[45] J. M. Boutwell, "The Salt Lake Region," *Sixteenth Internat. Geol. Cong., U. S., Guidebook 17* (1933), p. 86.

[46] J. D. Sears, *op. cit.*, p. 280.

[47] A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., "Correlation of the Jurassic Formations of Parts of Utah, Arizona, New Mexico and Colorado," *U. S. Geol. Survey Prof. Paper 183* (1936), p. 44, Fig. 15.

tionships it is probably Upper Triassic in age. The Thaynes has generally been classed as Lower Triassic in age.[48] The marine faunas in the lower part of the type Ankareh have not been studied, but Boutwell pointed out that they show general agreement with the Thaynes fauna. The Ankareh, therefore, is probably Lower Triassic in age.

In southern Utah and Arizona and in central and southeastern Wyoming are beds whose age has not been determined to the satisfaction of all, but which are generally classed as Upper Triassic. They are characterized in part by coarse clastic sediments and in places rest unconformably on the older Triassic rocks. These are such units as the Shinarump and Chinle of the Colorado Plateaus, the Jelm of southeastern Wyoming, and the Popo Agie of central Wyoming. The writers believe that the Stanaker is correlative with these formations, and like them should be assigned to the Upper Triassic.

It is of interest to note that early workers, in 1875 and 1876, correlated the conglomerate, here called the Gartra grit, with the Shinarump conglomerate of southern Utah and Arizona. Baker, Dane, and Reeside were the last writers to consider at any length the later Triassic rocks of the Uinta Mountains,[49] and the Stanaker formation, which they called Ankareh (?) at Vermilion Creek, at Dinosaur Quarry (Split Mountain), and at other localities in northwestern Colorado and northeastern Utah, was classed as Upper Triassic and correlated with the Chinle formation.

On the other hand, some geologists have suggested that the beds now called Stanaker may be Jurassic in age, and such a consideration can not be lightly dismissed. Because the writers correlate the Stanker with the Shinarump and the Chinle, and because the Chinle has yielded vertebrates considered to be Triassic types, a Triassic age is favored for the Stanaker. If, however, the paleontologic evidence furnished by the Chinle be overlooked, the physical relations of the Stanaker would favor its being considered as the introductory Jurassic unit. Both Boutwell and Mathews drew the Triassic-Jurassic boundary at the base of the Gartra grit on the basis of physical evidence. Reeside states, in respect to the Stanaker, that "The Ankareh (?) formation of the eastern Uintas . . . is most logically viewed as introductory to the Nugget."[50] In addition, Mathews[51] has reported a single *Trigonia* from the Nugget, and this has been cited by later writers in discussing the Jurassic age of the Navajo or Nugget. It must be recalled that Mathews included the Stanaker as the basal unit of his Nugget, and it is likely that the fossil came from the Stanaker formation, for he says the specimen

[48] M. Grace Wilmarth, "Lexicon of Geologic Names of the United States," *U. S. Geol. Survey Bull. 896* (1938), p. 2135.

[49] A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., *op. cit.*

[50] J. B. Reeside, Jr., "Triassic-Jurassic Red Beds of the Rocky Mountain Region: A Discussion," *Jour. Geol.*, Vol. 37 (1929), pp. 56–57.

[51] A. A. L. Mathews, *op. cit.*, p. 42.

was found in " . . . the sandstones near the base above the conglomerate." The value of a single fossil, about which nothing is known other than the original report, is surely subject to question, however.

In summary it may be said that lithology and stratigraphic position favor a correlation of the Stanaker with the Shinarump and Chinle, whose Upper Triassic age seems well established. Other evidence suggests a possible Jurassic age.

JURASSIC STRATIGRAPHY

Heaton[52] was the first to correlate the Jurassic rocks between southeastern Idaho, the south flank of the Uinta Mountains, and northwestern Colorado. This work filled in the stratigraphy of an area not included by Baker, Dane, and Reeside in their treatise on the Jurassic formations of Utah, Arizona, New Mexico, and Colorado.[53]

The writers had independently reached the same conclusions as Heaton prior to the publication of his work, and are in complete accord with his correlations. Since Heaton gave no lithologic details of the various formations, other than by depicting them on a correlation chart and discussing them in general terms, the writers believe it worthwhile to make available the stratigraphic details. In addition, localities not discussed by Heaton are considered.

Nugget or Navajo sandstone.—As shown on the correlation chart (Fig. 8) and the diagram showing stratigraphic relations (Fig. 6), the Navajo or Nugget sandstone, everywhere along the Uinta Mountains, rests on the Stanaker formation. The contact of the massive cross-bedded Navajo with the older varicolored beds is not commonly exposed. Where visible it is sharp, but there is little physical evidence of an unconformity at that stratigraphic level. The lithology of the Navajo is uniform along the mountains, as given in the measured sections, but the color changes from salmon-pink along the western end of the range to white along the eastern part. On Rock Creek, about 12 miles east of the Duschesne River, the upper part of the Navajo is white and the lower part is salmon-pink. The color change cuts obliquely across the sandstone without regard to bedding. There is a general thinning from west to east, the thickness of the formation ranging from 1,293 feet at Weber River to 780 feet at Split Mountain. The thickness near Manila, on the north flank of the Mountains, is 838 feet.

Twin Creek limestone and Carmel redbeds.—In the western part of the Uinta Range the thick marine Twin Creek limestone overlies the Nugget. Along the Weber River the Twin Creek consists of 1,351 feet of light gray limestone, shaly limestone, and calcareous shale; certain beds containing abundant columnals of *Pentacrinus* and specimens of *Trigonia*, *Camptonectes*, and other invertebrate fossils. Eastward the Twin Creek thins in a short distance, the major thinning taking

[52] Ross L. Heaton, "Contribution to Jurassic Stratigraphy of Rocky Mountain Region," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 23, No. 8 (1939), pp. 1172–77, Fig. 10.

[53] A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., *op. cit.*

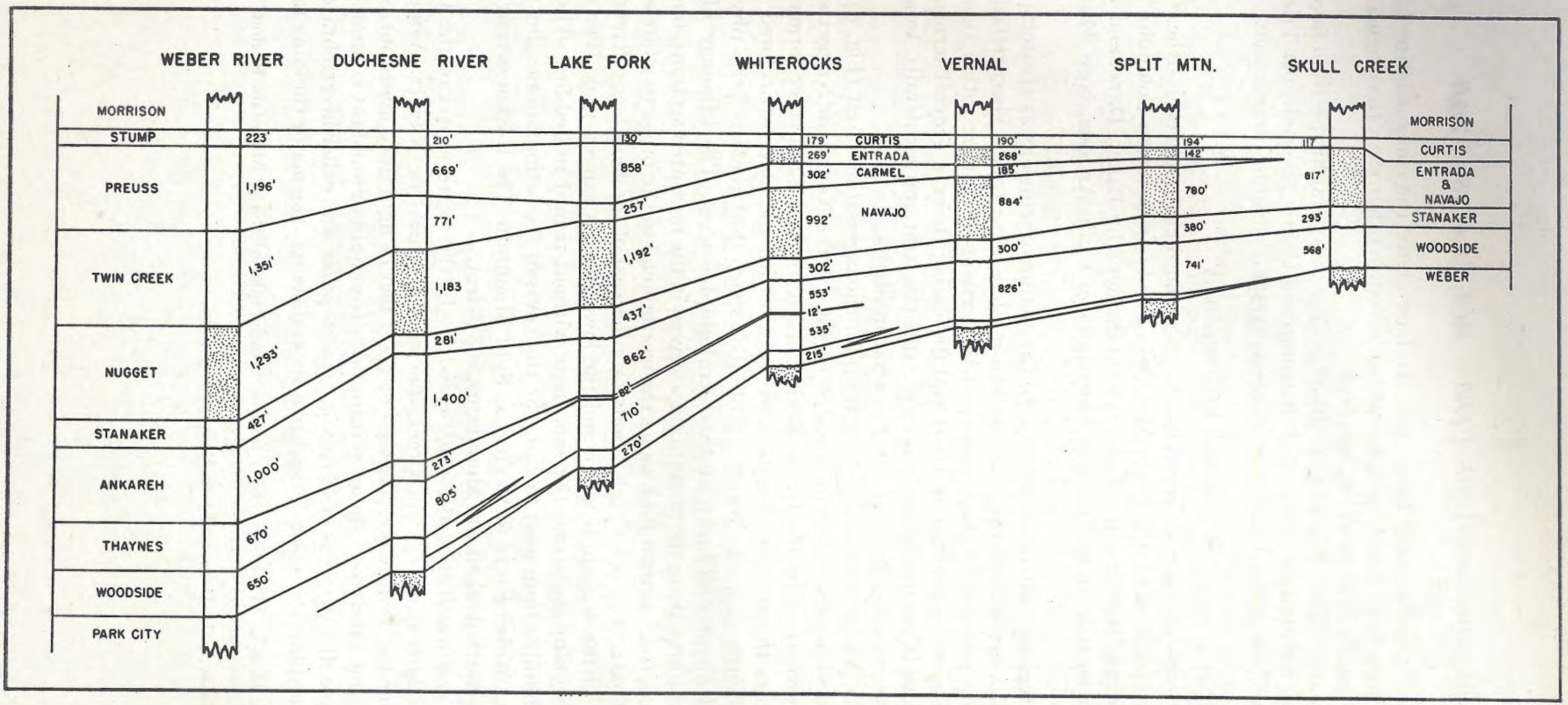


FIG. 8.—Correlation of formations along south flank of Uinta Mountains.

place between the Duchesne River (771 feet) and Lake Fork (257 feet). Between Lake Fork and Whiterocks Caynon, the Twin Creek is replaced by the Carmel redbeds, but thin tongues of marine limestone extend eastward as far as Deep Creek, where *Trigonia* was found in a 10-foot limestone separated from the Navajo sandstone by 30 feet of red shale. This bed was traced eastward as far as Stanaker Draw, north of Vernal, by R. W. Burns,[54] who reports that it is fossiliferous throughout that area. In the Vernal area the Carmel is mainly redbeds, with gypsum or lighter-colored beds in places. The Carmel thins eastward from Whiterocks Canyon and is absent in the section on Skull Creek, although Heaton found it present but very thin in that area, probably at a point west of the place where the writers measured their section. At Vermilion Creek, the Carmel consists of 20 feet of red shale which was included by Sears[55] in the Nugget sandstone. East of the wedge-edge of the Carmel, the cross-bedded Entrada sandstone, which overlies the Carmel in the eastern part of the Uinta Mountains, rests directly on the Navajo sandstone and, because of lithologic similarity, there is no apparent demarcation between the two sandstones.

On the north flank of the mountains, near Manila, the Carmel comprises 324 feet of redbeds and gypsum, with fossiliferous beds near the base containing *Camptonectes*, and *Trigonia*.

Preuss redbeds and Entrada sandstone.—Along the Weber River, at the western end of the Uintas, the Twin Creek is overlain by about 1,200 feet of redbeds which are not well exposed and which represent the Preuss formation of southeastern Idaho. These beds apparently comprise unit No. 7 of Stanton's section[56] published in 1893. The Preuss thins eastward and on Farm Creek, near the Duchesne River, is well exposed and comprises 669 feet of pink-red shales, siltstones, and very fine-grained sandstones. The Preuss thickens to 858 feet at Lake Fork. The writers believe that there the lower part represents the upper Twin Creek of sections on the west and is, therefore, related to the Carmel, but because of poor exposures at Lake Fork there is difficulty in separating the Preuss redbeds from Carmel redbeds (Fig. 6). East of Lake Fork the Preuss is replaced by a facies of decidedly different lithologic character—the cross-bedded Entrada sandstone. The main difference between the two is that the Preuss consists of silty plane-bedded redbeds and the Entrada is a cross-bedded clean quartz sandstone which is pink or white in color. Baker, Dane and Reeside[57] have shown that the Entrada of southern Utah comprises two facies—a red earthy sandstone facies on the west which grades into a cross-bedded sandstone facies on the east. This gradation is probably comparable with that between the Preuss and the Entrada along the Uintas. The Entrada persists eastward with but little change until it merges with

[54] R. W. Burns, personal communication (1941).

[55] J. D. Sears, *op. cit.*, p. 280.

[56] T. W. Stanton, "The Colorado Formation and Its Invertebrate Fauna," *U. S. Geol. Survey Bull. 106* (1893), p. 44.

[57] A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., *op. cit.*, Fig. 12, p. 49.

the Navajo because of the thinning-out of the intervening Carmel. In the Vermilion Creek section the Entrada was included in the Nugget by Sears.[58]

At Manila, on the north flank of the mountains, the Entrada shows a composite of the two lithologic types; a lower unit made up mainly of typical cross-bedded Entrada sandstone and an upper unit made up mainly of pink-red siltstone representing the Preuss lithology (Fig. 9).

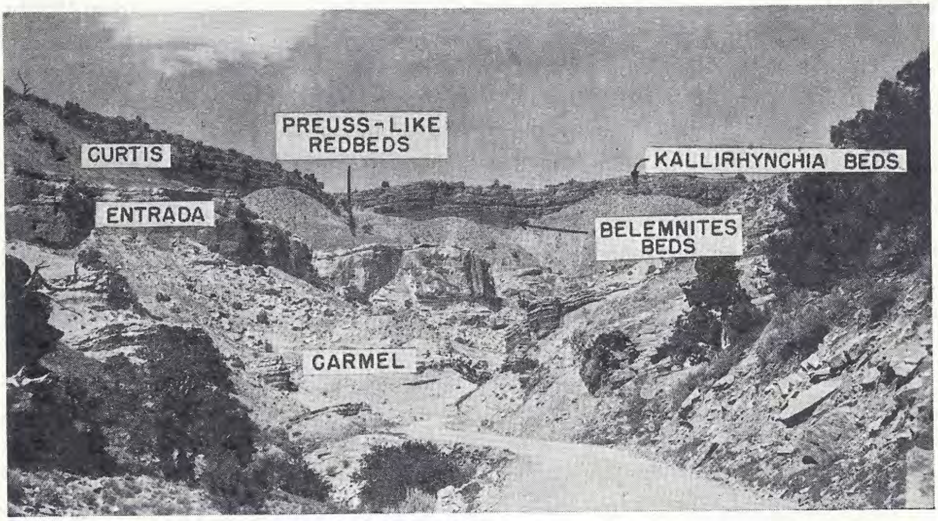


FIG. 9.—Jurassic formations exposed along Manila-Vernal road about 5 miles south of Manila, Utah.

Stump sandstone and Curtis formation.—Along the Weber River the Preuss is overlain by 223 feet of sandstones and shales which were classed as Stump by Heaton,[59] and as Curtis (?) by Eardley.[60] Although Stanton[61] reported *Trigonia* from this unit nearly 50 years ago, no later paleontologic evidence has been given to confirm the Stump, or Curtis, age of the beds. After much searching the writers were able to find three specimens of *Belemnites densus*,[62] and this fossil is abundant in a widespread zone over parts of Utah, Idaho, Colorado, Wyoming, and Montana. *Belemnites densus* has been reported from the type Stump of Idaho and was

[58] J. D. Sears, *op. cit.*, p. 280.

[59] Ross L. Heaton, *op. cit.*, Fig. 10.

[60] A. J. Eardley, *op. cit.*, pp. 837–38.

[61] T. W. Stanton, *op. cit.*, p. 44.

[62] *Belemnites densus* has recently been referred by various authors to the genus *Pachyteuthis*, but for the time being the writers prefer to retain the more familiar name for this well known index fossil.

found by the writers in the Stump or in the Curtis of every section studied around the Uinta Mountains. The name, Stump, is used by the writers in the Weber River, the Duchesne River, and Lake Fork areas so that the southeastern Idaho Jurassic terminology is uniformly used in all the western sections. East of Lake Fork, however, the name, Curtis, is used and along the eastern part of the mountains the lithologic character is somewhat different from that on the west. In general the Curtis is made up of a basal medium-grained to coarse-grained cross-bedded sandstone which rests with sharp contact on the subjacent beds. The middle part of the formation is greenish gray shale with intercalated fossiliferous sandstones, limestones, and coquinal limestones. The Curtis at Whiterocks Canyon and near Vernal and Manila has a conspicuous limestone member at the top which is characterized by abundant specimens of the brachiopod genus *Kallirhynchia.* Glauconite is one of the characteristic features of the Curtis and occurs as small nodules or grains in sandstones, shales, or limestones. The Twin Creek of Sears' Vermilion Creek section[63] is the Curtis; *Kallirhynchia* occurs at the top and *Belemnites* is abundant farther down.

There is a suggestion of an unconformity at the base of the Stump or Curtis. In the SW. ¼ of Sec. 30, T. 1 N., R. 6 W., between Lake Fork and the Duchesne River, the basal Stump rests on an irregular surface below which about 2 feet of upper Preuss is truncated in a horizontal distance of about 50 feet. J. C. Hazzard[64] has reported that there is a similar relation near the W. ¼ corner of Sec. 10, T. 1 S., R. 9 W., where at least 50 feet of upper Preuss is cut out below the basal contact of the Stump over a distance of about ½ mile.

Morrison formation.—The stratigraphy of the Morrison formation along the Uinta Mountains and in contiguous areas has been described recently by Stokes.[65]

Correlation with Wyoming Jurassic rocks.—Since the Jurassic units in the Manila section, on the north flank of the Uintas, can be confidently correlated with those on the south flank, that section serves as a key in correlating the Jurassic formations of central Utah, described by Baker, Dane, and Reeside,[66] with those in Wyoming to the north of the Uintas.

Thomas examined cores from the Jurassic section in the Selegna Petroleum Corporation's Hardy well No. 1 in Sec. 11, T. 20 N., R. 104 W., in the North Baxter Basin gas field in Wyoming, about 60 miles north of the Manila section. Although coring was not continuous, the following units were differentiated.

MORRISON: Variegated shale
CURTIS: About 120 feet thick; glauconitic limestones, shales and sandstones; *Kallirhynchia* not far below top
ENTRADA: About 95 feet thick; gray sandstone

[63] J. D. Sears, *op. cit.*, p. 280.

[64] J. C. Hazzard, personal communication (1941).

[65] W. L. Stokes, "Morrison and Related Deposits in and adjacent to the Colorado Plateau," *Bull. Geol. Soc. America*, Vol. 55 (1944), pp. 951–92.

[66] A. A. Baker, C. H. Dane, and J. B. Reeside, Jr., *op. cit.*

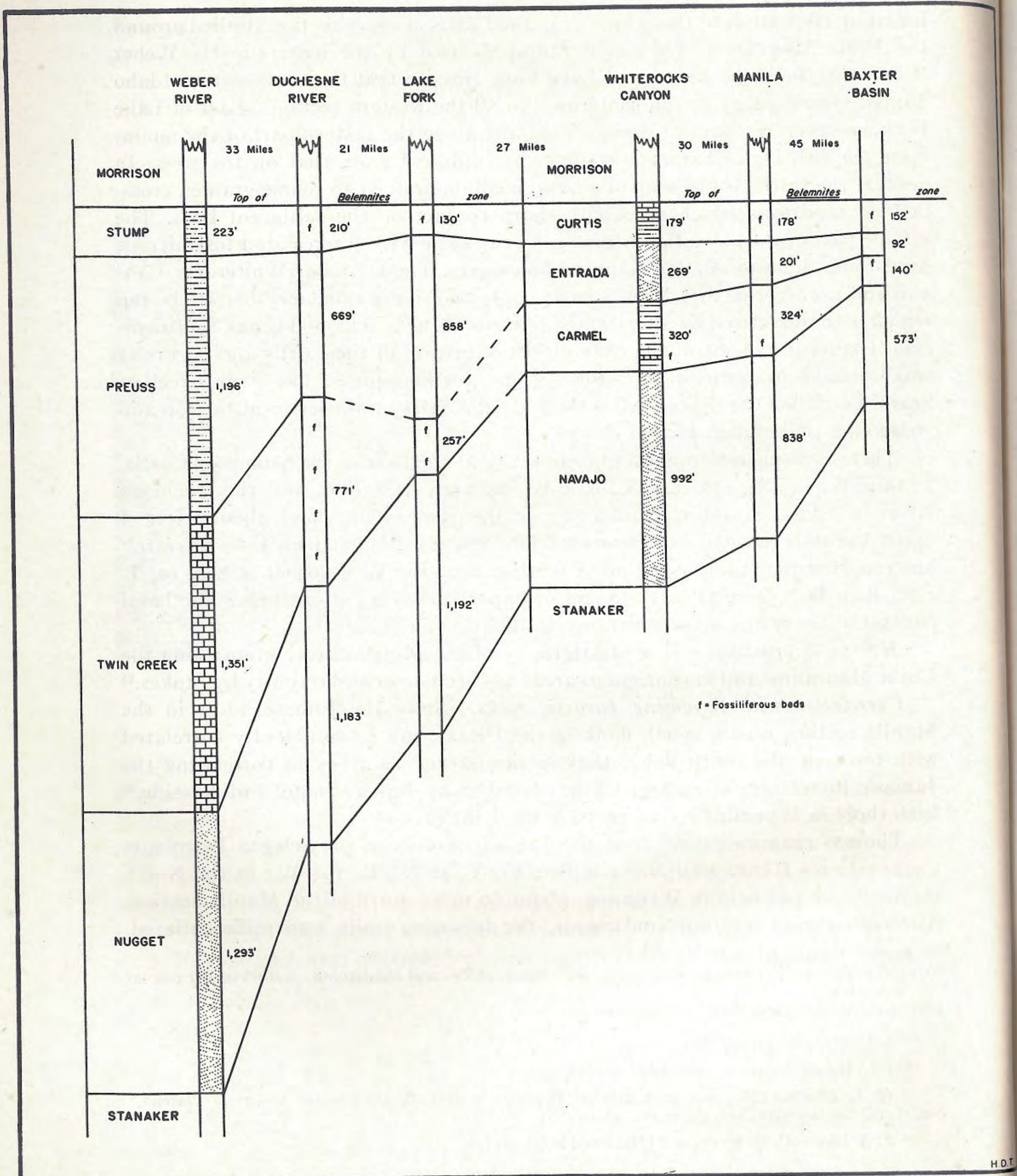


FIG. 10.—Correlation of Jurassic formations between Uinta Mountains and Baxter Basin gas field, Wyoming.

TWIN CREEK OR CARMEL: At top; about 100 feet of dark limestones and calcareous shales with fragments of marine fossils; lower part, 75 feet of red and green shales with a 5-foot bed of anhydrite. A 50-foot gap intervened between these cores and those representing the subjacent formation
NUGGET OR NAVAJO: 200 feet plus; gray sandstone

In March, 1941, a group of geologists[67] met to study cores from the Red Desert Oil Company's Edith Aspden well No. 1 in Sec. 34, T. 18 N., R. 103 W., in the South Baxter Basin field. The following lithologic descriptions were prepared by W. T. Nightingale for the units differentiated (Fig. 10).

CURTIS: 152 feet; glauconitic greensands and sandy limestones with some oölitic limestone layers; grayish green sandy shale at base; *Belemnites densus* present
ENTRADA: 92 feet; gray to white medium fine-grained sandstone
TWIN CREEK: 140 feet; upper part microcrystalline limestone with argillaceous limestone and shale partings; middle part greenish gray silty calcareous shale; lower part brown microcrystalline limestone with green shale partings
NUGGET: 573 feet; light-colored massive medium-grained sandstone
JELM (Stanaker equivalent): 380 feet; upper 170 feet, green dolomitic shales and brown silty dolomite; middle 150 feet, maroon silty shale; basal 60 feet, white fine- to medium-grained sandstone containing pink feldspar grains in lower part

It is evident, therefore, that both Twin Creek and Carmel lithologic types are present in the Baxter Basin area; the Twin Creek type represented by dark fossiliferous limestones and the Carmel type by red and green shales and anhydrite.

Recently Love *et al.*[68] and Imlay[69] have discussed the Jurassic formations of the Wind River Basin in central Wyoming, north of the Baxter Basin field, recognizing Nugget sandstone at the base overlain by Gypsum Spring, lower Sundance, upper Sundance, and Morrison. It is suggested on the basis of stratigraphic sequence and lithologic similarity that the Navajo, Carmel, Entrada, and Curtis of the Manila area are to be correlated with the Nugget, Gypsum Spring, lower Sundance, and upper Sundance of the Wind River Basin. There can be little question of the correlation of Navajo with Nugget and of Curtis with Upper Sundance. There is some question, however, on the correlation of the Carmel with the Gypsum Spring and the Entrada with the lower Sundance. Because the Carmel and the Gypsum Spring are both gypsiferous redbed sequences resting directly on the Navajo or Nugget sandstone, the writers would correlate these units. Imlay, however, on a paleontologic basis, correlates the Carmel of central Utah with the lower Sundance of the Wind River Basin, rather than with the Gypsum Spring.[70]

[67] A. E. Brainerd, S. H. Knight, C. S. Lavington, R. W. Mallory, W. T. Nightingale, J. B. Sansone, R. L. Sielaff, and H. D. Thomas.

[68] J. D. Love *et al.*, "Stratigraphic Sections and Thickness Maps of Jurassic Rocks in Central Wyoming," *U. S. Geol. Survey Prelim. Chart 14*, Oil and Gas Inves. (1945).

[69] Ralph W. Imlay, "Occurrence of Middle Jurassic Rocks in Western Interior of the United States," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29, No. 7 (1945), pp. 1019–27.

[70] Ralph W. Imlay, *op. cit.*, Table 1.

STRATIGRAPHIC SECTIONS

Weber River Section

Stratigraphic section measured on east side of Weber River, just north of Peoa, T. 1 S., R. 5 E., Summit County, Utah, by Horace D. Thomas and Max L. Krueger.

	Thickness in Feet
Lower Part of Morrison	
Red, lavender, and mauve clay shales with purple, tan, or white sandstones which vary in texture from fine-grained to conglomeratic. Limestone noduels common in clay shales at certain horizons and polished pebbles (gastroliths?) in middle of interval	432
Light gray dense crinkly algal (?) limestone	2
Red shale	2
Gray siliceous algal (?) limestone with questionable fossil fragments	1
Pink shale	3
Stump	
Greenish gray to tan hard fine-grained quartzitic sandstone; upper 4 feet calcareous, with obscure fragments of fossil shells; *Belemnites densus* rare	40
Gray to tan flaky shales, sandy shales, and thin sandstones	142
Flesh-colored soft platy cross-bedded medium-grained sandstone	41
Thickness of Stump	223
Preuss	
Poorly exposed pink-red siltstones and very fine-grained sandstones	1,196
Thickness of Preuss	1,196
Twin Creek	
Drab-gray very calcareous shale with interbedded thin flesh-colored limestones and thin fine-grained sandy limestones	211
Drab-gray calcareous shale, weathering splintery, with a few thin limestones	420
Platy thin-bedded to shaly limestone and sandy limestone weathering tan and gray	36
Light gray soft massive claystone	6
Medium dark gray calcareous shale, weathers splintery	45
Tan thin-bedded very fine-grained sandy limestone	40
Gray calcareous shale with two thin beds of red shale	72
Gray to blue thin-bedded to shaly limestone and calcareous shale with layers of coquinal limestone made up of small gastropods and *Pentacrinus* columnals; thin-bedded parts dense and brittle	521
Thickness of Twin Creek	1,351
Nugget	
Salmon-pink quartzitic sandstone, incompletely exposed	

Stratigraphic section measured from Mahogany Hills, north of the Weber River, to the mouth of Franson Canyon, south of the Weber River, T. 1 S., R. 6 E., Summit County, Utah, by Horace D. Thomas and Max L. Krueger.

	Thickness in Feet
Twin Creek	
Basal part gray to blue thin-bedded limestone and calcareous shale	
Nugget	
Salmon-pink massive cross-bedded friable medium-grained sandstone	1,293
Thickness of Nugget	1,293
Stanaker	
Mainly covered; pink and gray platy thin-bedded ribbon limestone at top just below Nugget; lower part shows isolated exposures of bright red platy sandstones, gray and red mottled massive sandstones, red siltstones, and bright red shales	394

	Thickness in Feet
Gartra grit member: Gray coarse-grained feldspathic quartz grit with scattered quartz pebbles ranging up to ½-inch in diameter; quartzitic, resistant, and forms a ridge	33
Thickness of Stanaker	427
ANKAREH	
Redbeds, not well exposed; mainly red thin-bedded fine-grained sandstones and siltstones. (After completion of field work and during computation of thicknesses, it became apparent that two measurements made across the Ankareh were in disagreement. The two measurements averaged 1,000 feet, and that figure is here used.)	1,000
Thickness of Ankareh	1,000
THAYNES	
Upper part, gray, tan, and brown platy limestones and tan, yellow, and gray sandstones, all fossiliferous; lower part, gray limestone weathering gray and dark brown, thin- to heavy-bedded, dense or very finely crystalline, with abundant fossils at certain levels	670
Thickness of Thaynes	670
WOODSIDE	
Dark red shales, siltstones and fine- to medium-grained sandstones; some beds very micaceous, some ripple-marked; near middle is a 50-foot pink cross-bedded medium-grained ridge-forming sandstone	650
Thickness of Woodside	650
PARK CITY	
Pink and white mottled limestone at top; next below is blue-gray and lavender limestone with *Punctospirifer pulcher* and numerous bryozoans; next below is gray cherty limestone; lower half of unit comprises medium-grained sandstones, cherty sandstones, gray very cherty limestone, and bedded chert	307
Black fetid phosphatic shale with abundant *Nucula* (?) in lower few inches; in talus are fragments of dark dense limestone and of oölitic phopshate rock	45
Black fossiliferous chert	3
Dark gray heavy bedded cherty quartzite with geodes, chert laminae and nodules, and beds of silicified coquina, one as much as 5 feet thick; *Schizodus* common; one specimen of shark denticles	41
Covered; an isolated exposure about 150 feet stratigraphically below top is a gray cherty limestone with *Orbiculoidea utahensis.*	

DUCHESNE RIVER SECTION

Stratigraphic section measured along Farm Creek in southern part of T. 1 N., R. 7 W., and northern part of T. 1 S., R. 7 W., several miles west of Hanna, Duchesne County, Utah, by Horace D. Thomas.

	Thickness in Feet
LOWER PART OF MORRISON	
Red shale with several beds of white medium grained sandstone	533
STUMP	
Dark gray flaky shale	5
Yellow soft friable fine-grained sandstone	22
Dark gray shales with thin beds of coquinal limestone and of fine-grained glauconitic sandstone; *Belemnites densus* and other typical Stump fossils common	111
Yellowish gray heavy bedded cross-laminated ripple-marked friable medium- to coarse-grained sandstone; upper part softer than basal part which forms a cliff	72
Thickness of Stump	210

	Thickness in Feet
PREUSS	
Pink-red very fine-grained sandstone with intercalated beds of thin-bedded siltstone and of red shale	285
White massive fine-grained sandstone	4
Pink-red massive to thin-bedded fine- to medium fine grained sandstone with interbedded siltstones at top; downward becomes less sandy and lower part is pink-red soft blocky siltstone with some shaly beds	380
Thickness of Preuss	669
TWIN CREEK	
Gray and greenish gray platy finely laminated calcareous shale	68
Gray shale with thin layers of brown finely laminated siltstone	4
White massive fine-grained calcareous sandstone	8
Greenish gray and red shales with thin beds of brown platy limestone	114
Greenish gray thin-bedded to finely laminated sandy limestones, calcareous siltstones, and sandy shales	109
Light gray, greenish gray and grayish green thin-bedded to finely laminated sandy limestones, calcareous shales and calcareous siltstones with several thin red shale layers; some beds ripple-marked	204
Light gray thin-bedded dense porcellaneous limestone	105
Red shale	10
Dark gray fossiliferous thin-bedded oölitic limestone, finely crystalline limestone, and shaly limestone, all weathering light gray; upper 20-feet platy and forms a ledge; *Pentacrinus* and other Twin Creek fossils common	149
Thickness of Twin Creek	771
NUGGET	
Sandstone, uppermost part lavender, hard and cross-bedded; 15 feet near top bright red and plane-bedded; major part salmon-pink massive cross-bedded sandstone	1,183
Thickness of Nugget	1,183
STANAKER	
Red flaky shale	2
Greenish gray thin-bedded fine-grained sandstone; grades down into subjacent bed	1
Salmon-pink thin-bedded fine-grained sandstone; resistant and caps a hogback	5
Apple-green flaky shale	9
Green, brown, and red mottled thin-bedded very fine-grained calcareous sandstone	4
Pink massive clayey siltstone	11
Redbeds, covered, petrified wood in float near base; ½ mile to west ocher beds lie in part of this interval	223
Gartra grit member: Mottled gray and pink cross-bedded quartz grit with scattered quartz pebbles ranging up to ½ inch in diameter; hard and firmly cemented; forms a hogback	26
Thickness of Stanaker	281
ANKAREH	
Redbeds; not measured. W. C. Rauch measured an interval of 1,680 feet between base of Nugget and top of Thaynes several miles west of Farm Creek.	

Stratigraphic section measured along the Duchesne River, north of Hanna, in T. 1 N., R. 8 W., Duchesne County, Utah, by W. C. Rauch and checked in the field by Horace D. Thomas and Max L. Krueger.

	Thickness in Feet
ANKAREH	
Brick-red shale, sandy shale, and very fine-grained red sandstone with several thin white sandstones. Exact thickness not determined, but interval from base of Nugget to top of	

	Thickness in Feet
Thaynes measured 1,680 feet. If thickness of Stanaker on Farm Creek (281 feet) be subtracted, approximate thickness of Ankareh is 1,400 feet	1,400
Thickness of Ankareh	1,400
Thaynes	
Tan to gray thin-bedded to thick-bedded sandy limestone with thin layers of calcareous sandstone; abundant fossils	273
Thickness of Thaynes	273
Woodside	
Red sandy shales and thin-bedded sandstones, some ripple-marked, with several thin lighter-colored sandstone beds	805
Thickness of Woodside	805
Park City	
Gray to creamy limestone, cherty limestone and geodal shaly limestone with a redbeds unit about 50 feet thick near middle; thickness estimated	300
Black phosphatic shale with beds of black limestone and nodular phosphate rock; thickness estimated	40
Tan sandy limestones, cherty limestones, and very fine-grained quartzites; thickness estimated	100
Approximate thickness of Park City	440
Weber	
Sandstone, not measured	

Lake Fork Section

Stratigraphic section measured along Lake Fork in Ts. 1 and 2 N., R. 5 W., Duchesne County, Utah, by Horace D. Thomas. Lower Morrison and Curtis measured on west side of Lake Fork in Sec. 2, T. 1 N., R. 5 W. Section from Curtis through Park City measured from NW. ¼ of Sec. 1, T. 1 N., R. 5 W., northward to Mackentire Draw in Sec. 26, T. 1 N., R. 5 W.

	Thickness in Feet
Lower Part of Morrison	
Bright red flaky shale with one-inch layers of light gray sandstone in upper part	49
Olive-green flaky shale	3
Stump	
Light gray massive cross-bedded medium-grained calcareous sandstone	19
Gray shale, not well exposed; contains *Belemnites densus;* on east side of river this interval is composed of gray shale with gray fossiliferous glauconitic sandstones and coquinal limestones	79
Gray heavy-bedded to thin-bedded ripple-marked medium-grained sandstone; on east side of river *Eumicrotis curta* is abundant in parts of this bed; *Camptonectes* also occurs	32
Thickness of Stump	130
Preuss	
Redbeds, poorly exposed; isolated exposures show pink-red fine-grained shaly sandy siltstone and some light gray and greenish gray very fine-grained shaly sandstones and sandy shales	858
Thickness of Preuss	858
Twin Creek	
Light gray heavy bedded sandy limestone with coquinal layers made up almost entirely of *Trigonia* sp.; large *Camptonectes* and frilled *Ostrea* also occur in this bed	4
Poorly exposed pink very fine-grained siltstone, red shale, and gray shale	91

	Thickness in Feet
Gray, tan and pink dense limestone	30
Light gray porcellaneous limestone with interbedded shaly limestone and gray calcareous shale; carries *Pentacrinus*, *Camptonectes*, *Ostrea*, and minute gastropods	53
Light gray dense porcellaneous limestone at top grading down into heavier-bedded limestone which becomes thin-bedded and very sandy in lower 8 feet	79
Thickness of Twin Creek	257
NUGGET	
Gray to white massive cross-bedded medium-grained sandstone weathering creamy colored to tan; generally resistant but with softer parts	1,192
Thickness of Nugget	1,192
STANAKER	
Greenish gray sandy shale or shaly sandstone becoming red toward base; not well exposed	43
Pink-red thin-bedded fine-grained sandstone; forms ledges	41
Light gray dense heavy-bedded fine-grained sandstone	16
Redbeds, poorly exposed, mainly talus covered	269
Gartra grit member: Gray medium- to coarse-grained sandstone which downward becomes light gray to tan coarse-grained quartz grit and conglomeratic grit; basal part most conglomeratic, with quartz pebbles as large as 1 inch in diameter	67
Thickness of Stanaker	437
ANKAREH	
Olive-gray siltstone, grades downward into subjacent bed	10
Red siltstone and very fine-grained sandstone	114
Gray massive cross-laminated medium-grained sandstone with small calcitic pisolitic concretions	7
Red shale	16
Light gray medium-grained sandstone with small calcitic pisolitic concretions	11
Red flaky shales, finely laminated siltstones, and thin-bedded very fine-grained ripple-marked sandstones	415
White gypsum	4
Red siltstones and very fine-grained sandstones	285
Thickness of Ankareh	862
THAYNES	
White to light gray thin-bedded very fine-grained very calcareous sandstone and sandy limestone; forms ridge with subjacent bed	26
Light gray to tan thin- to heavy-bedded limestone and sandy limestone, resistant and forms a ridge; no fossils noted	56
Thickness of Thaynes	82
WOODSIDE	
Red thin-bedded siltstones and very fine-grained sandstones	316
White to light gray thin-bedded very fine-grained sandstone	15
Red flaky shales and siltstones	14
Greenish gray very fine-grained ripple-marked micaceous sandstone; hard and resistant	3
Red to maroon shales, siltstones and very fine-grained sandstones	357
Tawny to drab siltstone	5
Thickness of Woodside	710
PARK CITY	
Light gray dense limestone 5 feet thick at top; 70 feet cherty limestone and creamy chert next below; 10 feet lavender cherty limestone at base	85

	Thickness in Feet
Mackentire redbeds tongue of Woodside: Bright red shales, siltstones and very fine-grained sandstones	56
Yellowish cherty limestone and chert	67
Black shale with layers of phosphate rock and with beds of dense black limestone 1 to 5 feet thick in middle	62
Thickness of Park City	270

WEBER

Buff hard dense cross-bedded medium-grained sandstone; not measured

WHITEROCKS CANYON SECTION

Stratigraphic section measured on west side of Whiterocks River in SW. ¼ of Sec. 18 and NW. ¼ of Sec. 19, T. 2 N., R. 1 E., Uintah County, Utah, by Horace D. Thomas. Section of Jurassic rocks was also measured on east side of river in SE. ¼ of Sec. 18, T. 2 N., R. 1 E.

	Thickness in Feet
TERTIARY COVER	
CURTIS	
Gray thin-bedded cross-bedded oölitic fossiliferous limestone, parts sandy, *Kallirhynchia* sp. abundant	50
Gray shale with thin fossiliferous limestone beds ranging from a few inches to several feet in thickness; *Belemnites densus*	91
Gray thin-bedded cross-bedded medium- to coarse-grained sandstone; on the east side of the canyon this bed has a 1-foot chert pebble conglomerate at top	38
Thickness of Curtis	179
ENTRADA	
Soft pink-red very fine-grained silty sandstone and white very fine-grained sandstone; interval not well exposed but pink-red and white beds seem interbedded in about equal thicknesses	269
Thickness of Entrada	269
CARMEL (Measured on east side of river)	
Red shale and gray shale, very poorly exposed; this interval contains beds of gypsum on west side of river	181
White massive gypsum	5
Red shale	25
White massive gypsum	15
Red, gray and olive-green shales and sandy shales	21
Limestone; upper 10 feet light gray thin-bedded dense porcellaneous limestone; middle 3 feet gray calcareous shale; basal 4 feet very fossiliferous oölitic limestone in 6-inch beds; abundant *Trigonia* sp.	17
Gray, red and olive-green shales	40
Tan coquinal limestone with abundant *Camptonectes* sp.	1
Dark gray flaky shale becoming lighter in color and clayey near base	15
Thickness of Carmel	320
NAVAJO	
Dark, massive cross-bedded medium fine-grained tar-saturated sandstone; saturation is essentially complete and only where there are small calcitic concretions, small quartzitic patches, or tightly cemented ¼-inch laminae, is rock unsaturated	992
Thickness of Navajo	992

	Thickness in Feet
STANAKER	
Covered interval; suggestion of red, lavender, and ocher beds	259
Gartra grit member: Tan heavy-bedded cross-laminated coarse-grained quartz grit with sporadic quartz pebbles and here and there gray chert pebbles up to 1-inch in diameter	43
Thickness of Stanaker	302
ANKAREH	
Redbeds, very poorly exposed	553
Thickness of Ankareh	553
THAYNES	
White thin-bedded very fine-grained sandy limestone in beds from 1 to 2 feet thick, with interbedded red siltstones; two-thirds of interval is limestone; poorly preserved high-spired gastropods in basal limestone	12
Thickness of Thaynes	12
WOODSIDE	
Red shales and siltstones; lower part covered	535
Thickness of Woodside	535
PARK CITY	
Gray cherty limestone and bedded chert; forms ridge	68
Bright red sandy shale with small circular white spots; lower part covered in strike valley	58
Upper part; tan limestone, sandy limestone and sandstone; all cherty and with bedded chert at top; contains *Plagioglypta;* lower part greenish gray shales and siltstones, silicified oölites, and black phosphate rock, lithologic details not discernible	89
Thickness of Park City	215
WEBER	
Gray hard medium-grained sandstone cut by secondary quartz veinlets; some parts of upper 100 feet quartzitic; not measured	

VERNAL SECTION

Stratigraphic section measured north of Vernal, Uintah County, Utah, from Sec. 7, T. 3 S., R. 22 E., northward to a gorge tributary to gorge of Brush Creek near NW. cor. of Sec. 32, T. 2 S., R. 22 E., and west of the Vernal-Manila highway, by Horace D. Thomas.

	Thickness in Feet
LOWER MORRISON	
Variegated mauve, lavender, and maroon clay shales with thin brown lenticular sandstones and thin beds of chert pebble conglomerate	
CURTIS	
Gray thin bedded cross-laminated oölitic sandy limestone	5
Gray shales interbedded with thin gray sandy limestones	31
Gray thin-bedded cross-laminated oölitic limestone with abundant specimens of *Kallirhynchia*	12
Dark gray flaky shale and sandy shale with thin layers of gray sandstone and coquinal limestone in upper half; lower half much darker flaky shale; *Belemnites* present throughout	75
Gray soft coarse-grained glauconitic sandstone; thin beds of gray sandy shale in upper part	67
Thickness of Curtis	190
ENTRADA	
Pink, red or tan very soft, very fine-grained sandstone; not well exposed	197
White to tan very soft, almost unconsolidated, fine-grained sandstone	71
Thickness of Entrada	268

	Thickness in Feet
CARMEL	
Red and greenish shales alternating in about equal parts; red at top, then gray, then red, gray at base	85
White soft medium fine-grained sandstone	3
Red shale	3
Gray shale	5
Bright red shale and siltstone	89
Thickness of Carmel	185
NAVAJO	
Gray to cream to buff massive cross-bedded medium fine-grained sandstone weathering into knobs and turrets	884
Thickness of Navajo	884
STANAKER (Type section)	
Lavender clay shale	28
Tan thin-bedded medium-grained sandstone	5
Lavender clay shale	4
Red to tan heavy bedded to thin-bedded medium fine-grained sandstone; some parts silty and weather more readily; forms hogback	65
Red siltstone	3
Red thin-bedded fine-grained sandstone	6
Lavender and ocher clay shale with two 3-foot beds of massive medium-grained red sandstone	65
Yellow to ocher soft massive very calcareous sandstone and sandy limestone	4
Lavender and purple clay shale with thin red soft massive very fine-grained sandstones	34
Gray coarse-grained feldspathic quartz grit; locally quartzitic	3
Lavender clay shale	13
Gray coarse-grained feldspathic quartz grit	4
Lavender clay shale	6
Gartra grit member: Gray massive cross-bedded feldspathic quartz grit with sporadic quartz pebbles up to one inch in diameter; resistant and forms a hogback; rests on irregular surface truncating subjacent red Woodside shales; locally varies from 40 to 80 feet in thickness	60
Thickness of Stanaker	300
WOODSIDE	
Dark red shales, siltstones and very fine-grained sandstones	477
Tan, gray and red thin-bedded to finely laminated ripple-marked very fine-grained calcareous sandstone grading down into olive-gray shale	49
Tan thin-bedded to finely laminated very fine-grained calcareous sandstone	12
Gray to tan flaky shale	30
Red shale	10
Gray to tan flaky shale	43
Red flaky shale; within 500 feet along strike becomes gray	10
Olive-gray and tan flaky shale with thin slabby sandy beds	72
Brown thin-bedded ripple-marked very fine-grained calcareous sandstone; forms a ledge	6
Olive-gray and tan flaky shale with several thin brown platy very fine-grained sandstones	117
Thickness of Woodside	826
PARK CITY	
Gray heavy bedded dense limestone with much gray chert	6
Greenish gray flaky shale	5
Gray dense cherty limestone	7
Olive-gray shale at top grading downward into red shale below; about 10 feet thin-bedded yellow ocher siltstone at base	26
Gray thick-bedded limestone and sandy limestone with chert nodules and bedded chert; calcite geodes throughout; upper 5 feet with abundant *Plagioglypta* and *Euphemites*	25

	Thickness in Feet
Dark greenish gray and black phosphatic shale and thin beds of oölitic phosphate rock; upper part somewhat sandy and cherty, with quartz geodes	22
Thickness of Park City	91

WEBER

Creamy to tan massive cross-bedded medium-grained quartz sandstone; not measured

SPLIT MOUNTAIN SECTION

Stratigraphic section measured near mouth of gorge of Green River at Split Mountain, several miles east of Dinosaur National Monument, approximately along line between T. 5 S., R. 23 E., and T. 5 S., R. 24 E., Uintah County, Utah, by Horace D. Thomas.

	Thickness in Feet
LOWER MORRISON	
Variegated lavender, mauve, gray and green clay shale	
CURTIS	
Gray ripple-marked fine-grained sandstones with interbedded gray sandy shales	78
Dark gray fissile shale containing *Belemnites densus* and other typical Curtis invertebrates.	36
Gray heavy bedded to thin-bedded medium- to coarse-grained sandstone	60
Sandstone similar to above but thin layers of gray fissile shale	10
Gray heavy bedded to thin-bedded coarse-grained sandstone with impressions of pelecypods; contact with subjacent bed sharp	10
Thickness of Curtis	194
ENTRADA	
White to red sandstone, mottled on a large scale, which is soft, massive, cross-laminated and fine-grained; weathers into rounded domes, not along bedding planes	142
Thickness of Entrada	142
CARMEL	
Bright red shales, siltstones and very fine-grained sandstones with two 10- to 15- foot beds of gray shale	104
Thickness of Carmel	104
NAVAJO	
Tan soft massive cross-bedded fine- to medium-grained sandstone which weathers into smooth knobs and domes; basal contact sharp	780
Thickness of Navajo	780
STANAKER	
Lavender-red fine-grained sandstones and shales about 70 feet thick at top; red soft fine-grained sandstones with interbedded red shales aggregating about 70 feet in thickness in middle; lower part consists of lavender, red, and ocher shales	287
Gartra grit member: Gray cross-bedded coarse-grained quartz grit and conglomerate; parts are well sorted fine- to medium-grained sandstone, others are granule grits with angular to poorly rounded sporadic quartz pebbles up to 1 inch in diameter; resistant and forms hogback; rests with sharp irregular contact on subjacent bed	93
Thickness of Stanaker	380
WOODSIDE	
Brick-red to bright red shales and siltstones, with several thin harder very fine-grained sandstones	502
Brownish red massive medium- to fine-grained sandstone; forms a ledge	10
Brownish red thin-bedded to finely laminated siltstone and very fine-grained sandstone with about a dozen 1- to 4-inch gray, olive-green or tan layers	51

	Thickness in Feet
Gray, tan, and ocher firm platy claystone and siltstone with some red layers and red mottling	12
Red shale with several thin gray, yellow, or ocher sandy shales, calcareous shales and very fine-grained sandstones	113
Yellowish-tan calcareous micaceous siltstone	4
Red shale with thin very fine-grained sandstone layers	19
Yellow shaly mudstone	15
Yellowish gray massive very fine-grained sandstone with thin shale layers	15
Thickness of Woodside	741
PARK CITY	
Gray massive sandy limestone	2
Light gray to tan platy dense limestone with gray chert layers and nodules; lower part shaly	32
Gray thin-bedded to heavy bedded very sandy limestones, limy sandstones and dense gray limestones with large brown chert nodules and layers; contains *Plagioglypta* and *Euphemites* in upper half	42
Thickness of Park City	76
WEBER	
Gray massive cross-bedded sandstone with numerous small limy concretions which impart a pisolitic appearance to uppermost part; not measured	

SKULL CREEK SECTION

Stratigraphic section measured on south flank of Skull Creek anticline in T. 4 N., R. 101 W., Moffat County, Colorado, by Max L. Krueger.

	Thickness in Feet
LOWER MORRISON	
Variegated clay shales	
CURTIS	
Gray shale	44
Brown soft shales with thin gray sandstones and fossiliferous limestones; *Belemnites densus* and other Curtis invertebrates present	73
Thickness of Curtis	117
ENTRADA AND NAVAJO	
White to buff cross-bedded fine- to medium-grained sandstone with 25 feet of harder ledge-forming sandstone at top	576
White dense limestone	2
White to buff cross-bedded fine- to medium-grained sandstone	239
Thickness of Entrada and Navajo	817
STANAKER	
Upper part brick-red massive silty sandstone; lower part dark purplish, light red and brick-red shales	213
Mottled purple hard sandy shale	14
Gartra grit member: Grayish white massive cross-bedded feldspathic grit and pebble conglomerate; 3 feet red shale near middle	66
Thickness of Stanaker	293
WOODSIDE	
Red shales, siltstones and very fine-grained sandstones; some greenish gray shales	257
Red thin-bedded platy fine-grained sandstone	23

	Thickness in Feet
Buff to gray gypsiferous clay shale with a few thin sandstones at top; lower part orange-yellow shale with interbedded thin tan siltstones; basal contact sharp	288
Thickness of Woodside	568

WEBER

White to buff massive cross-bedded sandstone; not measured

MANILA SECTION

Stratigraphic section measured on north flank of Uinta Mountains, south of Manila, Dagget County, Utah, by Horace D. Thomas. Specific localities as follows: Section from Morrison to Navajo measured adjacent to Manila-Vernal Highway in Sec. 6, T. 2 N., R. 20 E.; section of Navajo and Gartra measured in Sec. 3, T. 2 N., R. 19 E.; section of upper Woodside measured about 1 mile south of Horseshoe Canyon west of Green River in Sec. 3, T. 2 N., R. 20 E.; and section of lower Woodside and Park City measured along Hide Out Canyon road in Sec. 3, T. 2 N., R. 20 E.

	Thickness in Feet
LOWER PART OF MORRISON	
Variegated clay shale; not measured	
CURTIS	
Gray heavy to thin-bedded hard dense crystalline limestone with abundant specimens of *Kallirhynchia myrina* in upper part; forms dip-slope of hogback	68
Dark gray shale with thin interbedded limestones; abundant specimens of *Belemnites densus*	110
Thickness of Curtis	178
ENTRADA	
Pinkish red siltstones and very fine-grained sandstones	84
Yellow massive cross-bedded fine- to medium-grained sandstone; resistant and forms a cliff	72
Pinkish red soft massive very fine-grained sandstone	25
White- and pink-mottled massive fine-grained sandstone	20
Thickness of Entrada	201
CARMEL	
Red and gray flaky shale and siltstone	101
Light gray gypsum	3
Very light gray shale with thin beds of gypsum and gypsum veinlets	41
Light gray heavy-bedded gypsum	9
Brick-red and light gray shale, interbedded	31
Light gray massive gypsum	5
Brick-red flaky shale with several interbedded greenish-gray flaky shale beds and two 6-inch beds of light gray fine-grained very calcareous sandstone	86
Dark gray heavy bedded coquinal and oölitic limestone split by several dark shale layers	22
Gray shale with thin layers of coquinal limestone	16
Brown slabby fossiliferous shaly limestone with *Camptonectes*, *Trigonia* and *Ostrea*	3
Dark gray flaky shale	7
Thickness of Carmel	324
NAVAJO	
Light gray to tan massive cross-bedded well sorted fine-grained sandstone; forms cliff throughout area	838
Thickness of Navajo	838
STANAKER	
Tan sandy shale sharply overlain by Navajo sandstone	10
Apple-green flaky shale	2

	Thickness in Feet
Greenish gray thin-bedded shaly siltstone and very fine-grained shaly sandstone	24
Purplish red shale	10
Purplish red irregularly bedded medium-grained sandstone interbedded with red shale	64
Purplish red limestone pebble and clay pebble conglomerate	5
Purplish red flaky shale	46
Gray hard very coarse-grained quartz sandstone and quartz granule grit; poorly sorted	3
Purplish red shale	15
Lavender, mottled with gray, hard cross-laminated medium- to coarse-grained sandstone	10
Lavender to red flaky shale	95
Gartra conglomerate member: Purplish red limestone pebble conglomerate in lenses set in purplish red cross-bedded coarse-grained sandstone. Rests with sharp irregular contact on subjacent beds	18
Thickness of Stanaker	302
WOODSIDE	
Red siltstone and very fine-grained sandstone with some red shale; weathers into a vertical scarp in places and is relatively resistant	349
Redbeds, softer than above and poorly exposed; weather with gypsum excrescence	245
Massive soft gypsum with thin breaks of bright-red shale	121
Tawny to greenish gray very fine-grained ripple-marked sandstones, limy sandstones, siltstones and micaceous shales, with thin beds of gypsum	406
Tan and gray fine-grained thin-bedded sandstones, sandy shales and siltstones; some beds calcareous; ripple-marks conspicuous; obscure molds of pelecypods in talus	239
Brown platy medium-grained sandstone	4
Tan to gray thin-bedded very fine-grained sandstones and sandy shales; basal contact sharp	91
Thickness of Woodside	1,456
PARK CITY	
Light gray dense siliceous limestone and coquinal limestone; upper part thin-bedded, lower part heavy-bedded; carries abundant bryozoans and *Euphemites subpapillosus*	19
Light gray dense heavy-bedded limestone with calcite geodes, nodular gray chert, and layers of white to gray chert	40
Interbedded gray flaky shale and light gray dense argillaceous limestone with calcite geodes and nodular gray chert	45
Ocher to yellow soft massive siltstone	15
Red and gray sandy shale	10
Gray gypsum or anhydrite, lenticular	1
Tan cross-bedded medium- to coarse-grained quartzitic sandstone	15
Interbedded gray dense heavy-bedded very cherty limestone and gray fine-grained sandstones; some thin tan shale breaks; sandy parts contain calcite geodes; *Plagioglypta* in talus	108
Black to very dark gray shale and oölitic phosphate rock, details obscure, forms slope	22
(Note: Following beds probably equivalent to lower part of Park City of western Uintas)	
Cliff-forming massive sandstone unit consisting mainly of massive to irregularly bedded buff to yellow very fine- to fine-grained sandstone with calcite geodes in lower part. Vertical variation is such that parts are calcareous and others shaly with gradations between; some beds siliceous or quartzitic; irregular patches of brown chert in upper part	105
Brown massive cross-laminated sandstone superficially like Weber but differs in minor details; rests on an irregular surface which has several feet of relief and which abruptly truncates the cross-bedding of the subjacent Weber sandstone	10
Thickness of Park City	390
WEBER	
Tan cross-bedded sandstone	