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Mr. Robert D. Nininger, Assistant Director
Division of Raw Materials
U. S. Atomic Energy Commission
Washington 25, D.C.

Dear Bob:

Transmitted herewith are three copies of TEI-319, "Stratigraphy of the Morrison formation in part of Northwestern New Mexico," by V. L. Freeman and L. S. Hilpert, April 1955.

We are asking Mr. Hosted to approve our plan to publish this report as a Survey bulletin.

Sincerely yours,

for *George N. Pipinings*
W. H. Bradley
Chief Geologist

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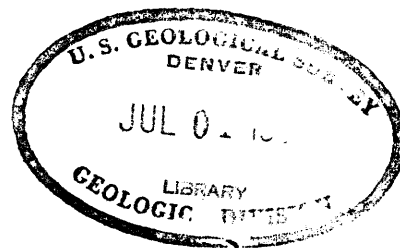
STRATIGRAPHY OF THE MORRISON FORMATION IN PART
OF NORTHWESTERN NEW MEXICO*

By

V. L. Freeman and L. S. Hilpert

April 1955

Trace Elements Investigations Report 319



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STRATIGRAPHY OF THE MORRISON FORMATION IN PART OF NORTHWESTERN NEW MEXICO

By V. L. Freeman and L. S. Hilpert

ABSTRACT

In the summer of 1954 while investigating the uranium resources of northwestern New Mexico, the authors noticed that the stratigraphic nomenclature of the Morrison formation in use in the Laguna area was not consistent with that in use elsewhere in the region. A review of the literature led the authors to the agreement that the nomenclature currently in use elsewhere in the area, such as near Grants, is satisfactory. This usage divides the Morrison formation into three members: in ascending order they are the Recapture member, the Westwater Canyon member, and the Brushy Basin member. These members may be recognized and have been correlated throughout northwestern New Mexico. In the Laguna area the Recapture, Westwater Canyon, and most of the Brushy Basin members, as correlated by the authors, are present in the stratigraphic interval that has previously been considered as Recapture. The sandstone previously considered as Westwater Canyon is in the authors' opinion at the top of the Brushy Basin. This sandstone is of economic importance and is informally named the "Jackpile sandstone."

INTRODUCTION

The field work on which this report is based was done during the summer of 1954 when the authors were engaged in investigating the uranium resources of northwestern New Mexico on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. While studying the uranium potential of the various stratigraphic units, a discrepancy between the nomenclature of the Morrison formation in the Laguna area and in other parts of northwestern New Mexico became evident. As correct correlations were a necessity in evaluating the resource potential of the stratigraphic units, the authors undertook a stratigraphic study to assure proper correlation. Eleven stratigraphic sections were measured in northwestern New Mexico, four sections measured by others were examined, and a review of the literature was undertaken. This paper reviews the names that have been proposed for the members of the Morrison formation in northwest New Mexico,

describes the members, and presents the results of the authors' work in correlating the members near Laguna with adjacent areas. The work was aided by the cooperation of the staffs of the mining companies in the area and the U. S. Atomic Energy Commission. Use was made of stratigraphic sections measured by L. C. Craig and T. E. Mullens of the U. S. Geological Survey.

PREVIOUS STRATIGRAPHIC WORK

The nomenclature of the Jurassic formations in northwestern New Mexico was summarized and a complete bibliography of the Jurassic literature was presented by Baker, Dane, and Reeside (1936, p. 43). This paper, together with a revision published in 1947 (Baker, Dane, and Reeside), is the standard reference on Jurassic stratigraphy in the region. In the earlier paper the Morrison formation in northwestern New Mexico included the Todilto limestone member at the base overlain in ascending order by a sandstone member and a shale member (Baker, Dane, and Reeside, 1936, table 8). In the revision, the Todilto limestone was removed from the Morrison formation (Baker, Dane, and Reeside, 1947, p. 1668). No attempt was made in these papers to subdivide the Morrison formation above the Todilto limestone into formal members.

The first subdivision of the Morrison formation on the Colorado Plateau was made by Lupton (1941) who gave the name Salt Wash sandstone member to a basal conglomeratic sandstone unit in east-central Utah. At Bluff, Utah (fig. 1), a massive sandstone that forms the cliffs along the San Juan River and locally referred to as the Bluff sandstone, was considered by Baker, Dane, and Reeside (1936, p. 21) as a member of the Morrison formation. Gregory (1938, p. 58), in the same area, recognized four members of the Morrison formation: the Bluff sandstone member at the base overlain by the Recapture shale member, the Westwater Canyon sandstone member, and the Brushy Basin shale member.

In 1947 the U. S. Geological Survey started a study of the stratigraphy of the Morrison formation on the Colorado Plateau (Craig and others, 1951). The study resulted in the definition of the distribution of the members of the Morrison formation in the Colorado Plateau region. As this study centered on the then known Morrison uranium ore deposits in western Colorado and eastern Utah, the Morrison formation of northwestern New Mexico was not investigated in detail. Craig tentatively assigned the Bluff sandstone,

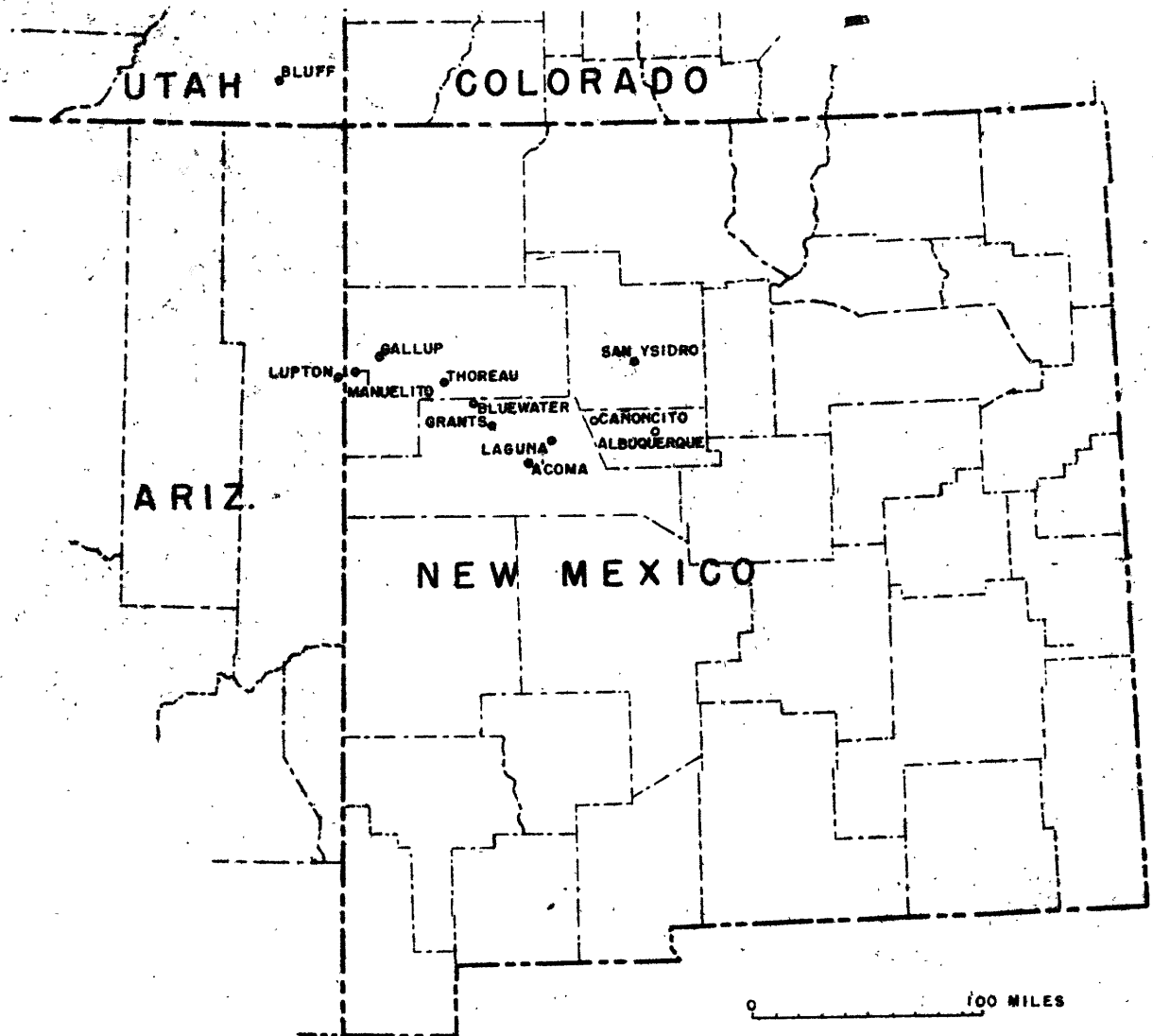


Figure 1. INDEX MAP OF PART OF NEW MEXICO AND ADJACENT STATES SHOWING LOCALITIES REFERRED TO IN TEXT

as a formation, to the upper part of the San Rafael group but retained as members of the Morrison formation in ascending order: the Salt Wash, Recapture, Westwater Canyon, and Brushy Basin. These assignments have been accepted by the Geologic Names Committee of the U. S. Geological Survey. The Salt Wash member was shown (Craig and others, 1951, p. 20 and 21) to extend from southeastern Utah a short distance into New Mexico, where it intertongues southwardly with the Recapture member and is absent from the rest of New Mexico. The remaining members of the Morrison formation, the Recapture, Westwater Canyon and Brushy Basin, were shown to extend to and beyond the Laguna area.

Before the extension of the Recapture, Westwater Canyon and Brushy Basin members of the Morrison formation into New Mexico, a set of informal member names was suggested by Kelley and Wood (1946) and adopted by Silver (1948) in the Laguna area. These were, in ascending order: the buff shale member, the brown-buff sandstone member, the white sandstone member, and the variegated shale member. Craig considered the buff shale member to be an equivalent of the Summerville formation and the brown-buff sandstone and the white sandstone members to be equivalents of the Bluff sandstone (Craig, personal communication). The variegated shale member apparently contains equivalents of the Recapture, Westwater Canyon and Brushy Basin members.

The discovery of commercial quantities of uranium ore in northwestern New Mexico in 1950, resulted in a study of the Jurassic sediments by the U. S. Atomic Energy Commission (Rapaport and others, 1952). The geologists of the U. S. Atomic Energy Commission recognized the presence of the Summerville formation and Bluff sandstone in the area of northwestern New Mexico east of Gallup (Rapaport and others, 1952, p. 20) and followed Craig's (Craig and others, 1951) terminology for the Morrison formation (table 1). This terminology has been widely accepted by the personnel of the mining companies.

Smith (1951, p. 13; 1954, p. 15) recently proposed a partly new set of names for the members of the Morrison formation (table 1). In the area near Thoreau, N. Mex., he divides the Morrison formation into the Chavez member at the base, stating that it may be equivalent to the Westwater Canyon member, and the Brushy Basin member at the top. The authors believe that the close similarity of the members of the Morrison in the Thoreau-Grants area with the members in southeast Utah could only be possible if they are continuous beneath the San Juan Basin. It, therefore, seems desirable to use the same

terminology especially as it is in general use by the mining companies in northwest New Mexico, rather than adopt the new terminology of Smith. In summary, the Morrison formation of northwestern New Mexico is considered to consist of the Recapture member at the base, the Westwater Canyon member, and the Brushy Basin member. A summary of the terminology is presented in table 1.

MORRISON FORMATION IN NORTHWESTERN NEW MEXICO

In the belt of outcrop of the Jurassic rocks between Gallup and Albuquerque, the Morrison formation as used here consists of three conformable members: the Recapture, Westwater Canyon, and the Brushy Basin. To the west, on the Navajo Indian reservation, several upper Jurassic units grade into a sand facies that has been named the Cow Springs sandstone (Harshbarger and others, 1951). At Lupton, Ariz., the Recapture and Westwater Canyon members of the Morrison are recognizable although with difficulty. Farther to the south the Recapture member grades into the Cow Springs sandstone leaving only the Westwater Canyon as a recognizable member of the Morrison formation because the Brushy Basin member is missing probably due to pre-Dakota erosion. About 3 miles east of Gallup where the Jurassic section crops out on the flank of the Zuni Uplift, the Recapture is recognizable although it is very sandy. A few miles farther east the Brushy Basin member appears beneath the Dakota sandstone, and in the area of concern in this report, the Morrison formation consists of the three members listed above.

Recapture member

The Recapture member in the Gallup-Albuquerque area ranges from about 20 to about 170 feet in thickness, in general thinning southward. It consists largely of grayish-red sandy claystone and clayey sandstone with limy nodules and white clean fine- to medium-grained sandstone in alternating units 5 to 10 feet in thickness. The clean sandstone beds are most common in the western part of the area and probably represent tongues of the Cow Springs sandstone. Clayey sandstone is the dominant rock type in the eastern and southern parts of the area. The Recapture in most of the area is conformable with the underlying Bluff sandstone, however, to the north near San Ysidro it rests directly upon the Summerville formation.

Table 1. Nomenclature of the Morrison formation in northwestern New Mexico

Baker, Dane, and Reeside 1936, 1947 Northwest New Mexico		Kelley and Wood 1946 Lucero Uplift, N. M.		Harshbarger and others 1951 Navajo Country		This paper; Craig and others, 1951; and Rapaport and others, 1952		Smith, Clay T. 1954 Thoreau Quadrangle	
Dakota sandstone		Dakota sandstone		Dakota sandstone		Dakota sandstone		Dakota sandstone	
Morrison formation	Shale member	Morrison formation	Variegated shale member	Morrison formation	Brushy Basin shale member	Morrison formation	Brushy Basin member	Morrison formation	Brushy Basin shale member
					Westwater Canyon sandstone member		Westwater Canyon member		Prewitt sandstone member
					Recapture shale member		Recapture member		Chavez member
					Salt Wash sandstone member		Salt Wash member		
Bluff sandstone member		White sandstone member		Cow Springs sandstone	Bluff sandstone	Bluff sandstone		Upper member	
		Brown-buff sandstone member							
		Buff shale member			Summerville formation		Summerville formation		Lower member
Todilto limestone member		Todilto formation		Absent		Todilto formation		Todilto formation	

In general the upper part of the usually clean Bluff sandstone is clayey, but the contact with grayish-red clayey sandstone of the overlying Recapture member is sharply marked. In the Laguna area the Recapture member interfingers with the Bluff sandstone. On Haystack Butte, near Bluewater, the basal unit of the Recapture shale is a conglomeratic sandstone that rests on a slightly channeled surface cut into the Bluff sandstone; they are distinguished on the basis of grain size and type of crossbedding.

The Recapture member generally is overlain by the Westwater Canyon member from which it is easily distinguished. A few miles south of Laguna the Recapture is composed of clayey sandstone beds that, because of the absence of the Westwater Canyon, are directly overlain by Brushy Basin beds of similar lithology. Near Ácoma, farther to the southwest, the two members could not be separated with certainty.

Westwater Canyon member

The Westwater Canyon member ranges from about 50 to 190 feet in thickness in the Gallup-Albuquerque area, but near Laguna it is locally absent. In general, the Westwater Canyon member thickens from the Laguna area toward Gallup to the west and toward San Ysidro to the north. The Westwater Canyon is a yellowish-gray to light grayish-red, locally conglomeratic, fine- to coarse-grained sandstone that is characterized by scour-and-fill-type crossbedding and by angular grains of unweathered feldspar. Discontinuous lenses of grayish-green sandy claystone are present. The Westwater Canyon interfingers with both the underlying Recapture and the overlying Brushy Basin members.

Brushy Basin member

The thickness of the Brushy Basin member is largely determined by the amount of deformation and erosion prior to the deposition of the Dakota sandstone. The details of the pre-Dakota deformation are not known; but, in general, it consisted of northeastward tilting and local broad folding. Subsequent erosion resulted in a southwestward irregular thinning of the Brushy Basin. In northwest New Mexico the member ranges in thickness from a knife edge to about 370 feet. The Brushy Basin consists of partly variegated but dominantly light greenish-gray, slightly swelling, locally sandy claystone with limy nodules.

Thick sandstone units lithologically similar to the Westwater Canyon, thin hard green sandstone beds, and thin clayey limestone beds are rare to common. Pinkish-orange jasper commonly occurs, especially near the base, as crack fillings and as cement in thin sandstones. As the Brushy Basin and the Westwater Canyon interfinger, the contact between the members may be difficult to determine. The authors placed the contact at the base of the lowest recognizable Brushy Basin claystone and acknowledge that some of the sandstone beds placed in the Brushy Basin may laterally be equivalent to the Westwater Canyon member.

STRATIGRAPHY OF THE MORRISON FORMATION NEAR LAGUNA, NEW MEXICO

The Morrison formation in the Laguna area became of economic importance with the discovery of uranium in 1951. As a consequence a great deal of geologic work is in progress in the area. The nomenclature of the Morrison formation in general use is that used by the authors, but it is not being applied to the same stratigraphic units. Table 2 compares the terminology in recent use with that proposed by the authors. The correlation of the members of the Morrison formation between Laguna and adjacent areas is made difficult because of: (1) the similarity of the ore-bearing sandstone unit, informally called "Jackpile sandstone" in this paper, with the Westwater Canyon member; (2) the local absence of the Westwater Canyon; (3) the unusual thickness of the Brushy Basin member; and (4) the thinness and incomplete exposures of the Recapture member.

Figure 2 shows the location of some of the measured sections studied and the relations of the members of the Morrison between the sections. The sections used are presented in the appendix. The Haystack Butte and Red Bluff sections are in the Grants area where there is general agreement on the nomenclature. At Haystack Butte the contact between the Westwater Canyon and the Brushy Basin is placed at the base of the lowest persistent claystone unit. Ledges of sandstone that could not be distinguished from the Westwater Canyon sandstone are present throughout the entire thickness of the Brushy Basin. Eastward toward the Red Bluff section the Westwater Canyon interfingers with the Brushy Basin and to a lesser extent with the Recapture resulting in a considerable thinning of the Westwater Canyon. Interfingering of the Recapture with the Bluff sandstone was not seen but may be present and may account for some thinning of the Recapture. The Morrison formation is not exposed in the area between the Red Bluff and Laguna sections.

Table 2. Nomenclature of the Morrison formation
in the Laguna area, New Mexico

Recent usage		This paper	
Dakota sandstone		Dakota sandstone	
Morrison formation	Westwater Canyon member	Morrison formation	"Jackpile sandstone"
	Recapture member		Brushy Basin member
Bluff sandstone		Bluff sandstone	
		Recapture member	

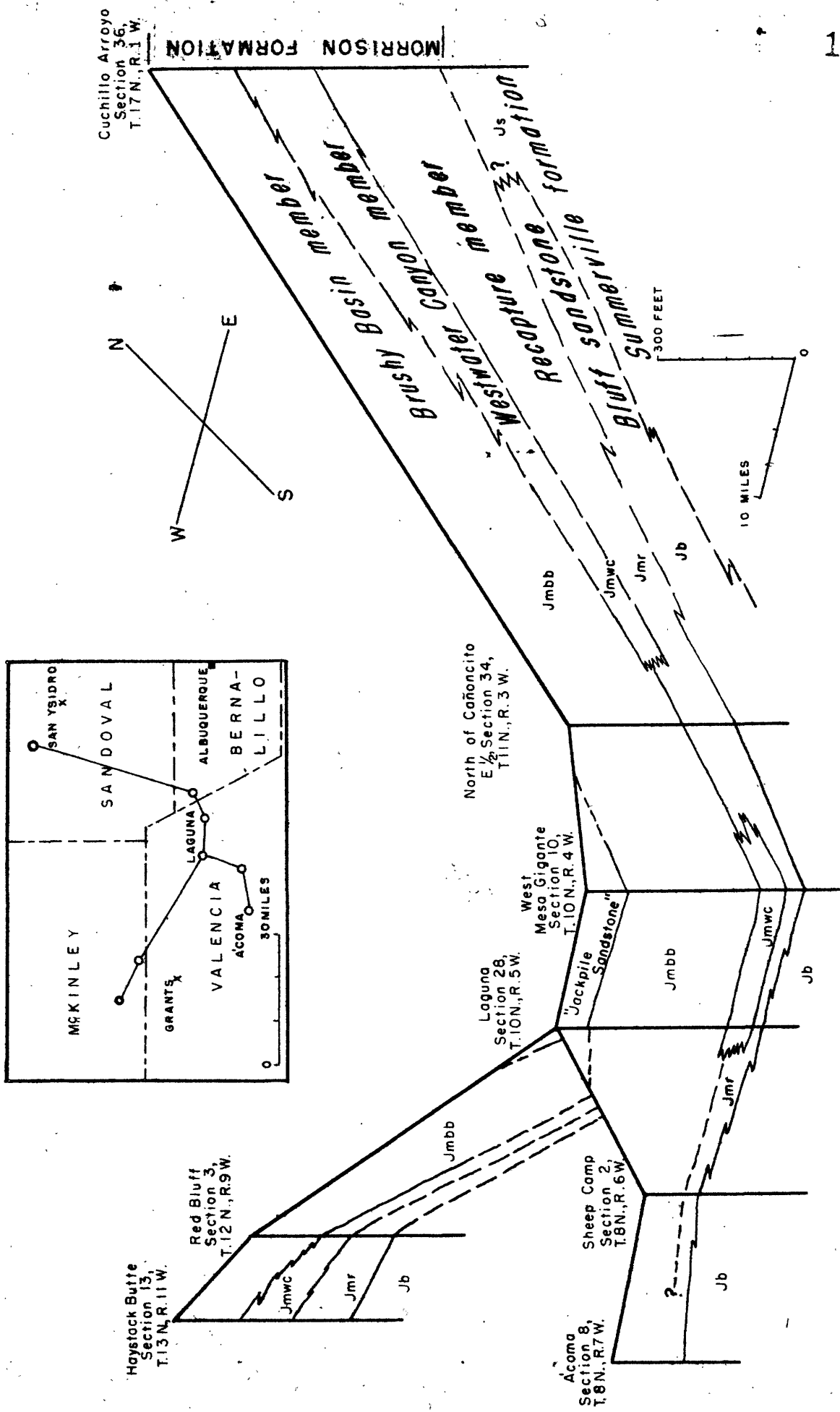


Figure 2. INTERRELATIONSHIPS OF THE MEMBERS OF THE MORRISON FORMATION

At the Laguna section, only the uppermost 29 feet of the Bluff sandstone is exposed. It is overlain by about 20 feet of reddish-brown and minor greenish-gray, very clayey sandstone with limy nodules that is typical of the Recapture member. Above the slope formed on the Recapture is a prominent ledge, about 55 feet thick, of the Westwater Canyon member. As no exposures of the Recapture exist between the Red Bluff and Laguna section, the manner of its thinning is not known. Silver (1948) showed that in this area the entire Jurassic thins southward by overlap against a Jurassic highland and the writers believe the thinning of the Recapture is probably due to the same cause.

The Westwater Canyon is very similar lithologically at the Laguna section and in the southeastern Utah area. It contains angular grains of unaltered feldspar, is moderately to poorly sorted, medium- to coarse-grained, and is scour-and-fill crossbedded. These features are in marked contrast to the dominantly well-sorted, fine-grained, and sweeping crossbedded Bluff sandstone, that is not known to contain the angular grains of unaltered feldspar. South of Laguna the Westwater Canyon is not present; it likely disappears by interfingering with the Recapture and Brushy Basin members.

At the Laguna section the Brushy Basin member is about 370 feet thick. It consists of grayish-green slightly swelling clay-rich beds with some pinkish variegations near the base and lenticular sandstone units lithologically similar to the Westwater Canyon sandstone. The Brushy Basin in the Laguna area is similar to the Brushy Basin in the Grants area and in southeast Utah but distinctly different from the Recapture member in these areas. At the Laguna section the uppermost 65 feet of the Brushy Basin is the "Jackpile sandstone" of the authors. It is a very pale orange and locally white sandstone that is dominantly fine- to medium-grained with minor coarse grains at the base. Feldspar grains, as well as specks of a white clay mineral, probably kaolin, are present. The sandstone is characterized by scour-and-fill crossbedding, but some parallel bedding, often marked by claystone partings, is present also.

Toward Acoma, beyond the limit of the Westwater Canyon member, the Recapture and Brushy Basin members are considerably thinner (fig. 2). The Recapture-Brushy Basin contact can be picked with reasonable certainty as far southwest as the Sheep Camp section (fig. 2), but farther to the southwest the contact is indistinct. The Brushy Basin becomes more variegated, grayish-red colors are prevalent, and it is very similar to the Recapture. At the Acoma section a reddish zone at the base of the Morrison may correlate with the Recapture, but this zone is gradational with the upper part of the formation which also contains thin reddish zones.

The West Mesa Gigante section is similar to the Laguna section; but, proceeding from the section southward along the west side of Mesa Gigante the Westwater Canyon member disappears in a few miles. It reappears for about a half a mile along the south face of the Mesa where it has a thickness of 58 feet; it does not reappear until about 3 miles north of Cañoncito along the east face of the Mesa where it is 47 feet thick. At this locality, S 1/2 sec. 27, T. 11 N., R. 3 W., the pinchout of the Westwater Canyon member is well exposed. In a distance of about 50 feet along the outcrop, the entire member, consisting of 47 feet of sandstone disappears by interfingering with sandy claystone beds of Recapture and Brushy Basin aspect (fig. 2). North of Cañoncito section, less than half a mile from the disappearance of the Westwater Canyon, the Recapture includes several sandstone beds of Westwater Canyon-type lithology.

Between the Cañoncito area and the Cuchillo Arroyo section only the upper part of the Morrison is exposed locally. At Cuchillo Arroyo 170 feet of Westwater Canyon is well exposed in a vertical cliff. It interfingers at top and base with the Brushy Basin and Recapture respectively. The Recapture rests directly upon the Summerville formation from which it is distinguished with difficulty. The manner in which the Bluff sandstone has disappeared is not entirely known, but as the Bluff has been seen by the authors to interfinger with both the Recapture and Summerville formation, a gradual thinning by interfingering with these units is at least partially responsible.

SUMMARY AND CONCLUSIONS

The Morrison formation in the area of Laguna, N. Mex., consists of a 20-foot unit at the base assigned to the Recapture member, a 55-foot sandstone assigned to the Westwater Canyon member, and a 370-foot unit assigned to the Brushy Basin member. The upper 65 feet of the Brushy Basin member is a sandstone that has been considered by others as the Westwater Canyon sandstone to which it is lithologically similar; the entire underlying Morrison, in consequence, was considered as Recapture shale. The members of the Morrison formation near Laguna are lithologically similar to the members in the area near Grants where there is general agreement of nomenclature, and in the San Ysidro area, where they are so typical as to preclude disagreement. The Recapture and the Westwater Canyon, however, are thinner near Laguna

because of proximity to the edge of their areas of deposition; and the Brushy Basin is much thicker, probably because of less removal prior to the deposition of the Dakota sandstone.

The sandstone occupying the uppermost part of the Brushy Basin member has been traced from the Laguna section, in nearly continuous exposures, into the ore-bearing sandstone at the Jackpile mine of Anaconda Copper Mining Company. It ranges from a knife edge, where cut out by pre-Dakota (?) erosion, to about 175 feet in thickness at the Jackpile mine. Because of the economic importance of this sandstone, it has been informally named the "Jackpile sandstone" and is included in the Brushy Basin member.

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APPENDIX

STRATIGRAPHIC SECTIONS OF THE MORRISON FORMATION

NEW MEXICO - VALENCIA COUNTY

LAGUNA section, NW-1/4, sec. 28, T. 10 N., R 5 W.

(Measured by L. C. Craig, V. L. Freeman, and T. E. Mullens)

Feet

Top of measured section

Dakota sandstone:

Sandstone, white (N9) 1/, to very pale orange (10YR8/2), weathering grayish orange (10YR7/4), fine- to medium-grained, well-sorted; composed of subrounded to rounded clear quartz with rare white accessory grains; well-cemented, calcareous; subparallel laminations filling shallow erosion troughs, thin- to medium-bedded, some ripple laminations. Conglomeratic sandstone near base, pebbles of gray and black chert, pebbles subangular to subrounded. Abundant plant impressions; some carbonaceous material. Unit forms vertical cliff 16.5

Morrison formation:

Brushy Basin member:

Sandstone, very pale orange (10YR8/2), locally white (N9) in upper part, predominantly fine- to medium-grained with rare coarse grains at base, well-sorted; composed of subangular to subrounded clear quartz with abundant pink feldspar grains and much interstitial kaolin, coarse grains are quartz, feldspar, granite, and rare red and brown chert; moderately well cemented; channeling with subparallel laminations filling erosion troughs; minor clay partings; unit forms ledgy slope with upper 16 ft. forming a vertical cliff. "Jackpile sandstone" 64.5

Claystone, grayish red (10R4/2) and light greenish gray (5GY8/1), very sandy (up to fine-grained); earthy weathering; slightly fissile; forms banded slope 17.8

1/ Colors established by comparison with Rock-color chart, E. N. Goddard, chairman

LAGUNA section--Continued

Morrison formation--Continued

Brushy Basin member--Continued

	Feet
Sandstone, very pale orange (10YR8/2) to yellowish gray (5Y8/1), medium- to coarse-grained, moderately sorted; composed of subrounded to rounded clear quartz with abundant pink and white accessory grains; friable, weakly cemented; bedding not visible; forms steep slope	12.7
Claystone, grayish red (10R4/2), very sandy (up to fine-grained); earthy weathering; slightly fissile	11.8
Sandstone, with claystone and limestone near top; sandstone, grayish yellow (5Y8/2) to white (N9), medium-grained with some very coarse grains at top, moderately sorted; composed of subrounded quartz with common pink and white accessory grains; very coarse grains at top are predominantly clear to white quartz, pink feldspar, and granite; well-cemented to friable; cross-laminations filling erosion troughs. Eight-ft. claystone and limestone unit below 10-ft, top ledge same as in unit below. Unit forms ledgy to rounded slope	33.7
Claystone, (90%) and limestone (10%). Claystone, dominantly light greenish gray (5GY8/1), with some yellowish gray (5Y8/1) and at base pale red (5R4/2) to grayish red (10R4/2), silty to sandy (fine-grained). Limestone, very light gray (N8), weathers white (N9), dense to finely crystalline. Unit weathers to steep rubble-covered slope	46.4
Sandstone, conglomeratic, very pale orange (10YR8/2) to yellowish gray (5Y8/1), very fine- to coarse-grained, poorly sorted; composed of subangular and subrounded clear quartz with abundant pink feldspar and uncommon white and green accessory grains.	

LAGUNA section--Continued

Morrison formation--Continued

Brushy Basin member--Continued

Feet

Conglomerate consists mainly of tan, brown, gray, and red chert pebbles and granules averaging 3/4 in. with maximum 1-1/2 in. in diameter, and abundant pink feldspar and white to clear quartz grains averaging 1/8 in. with maximum 1/2 in. in diameter; cross-laminations filling erosion troughs; locally forms prominent ledge.

Coarser material concentrated at base of unit 14.4

Claystone (85%), sandstone (10%), and limestone (5%). Claystone, yellowish gray

(5Y8/1) to light greenish gray (5G8/1) and yellowish gray (5Y7/2), slightly silty to slightly sandy (up to fine-grained); frothy weathering, forms pastel green and pink

slope. Sandstone, light greenish gray (5G8/1) to very light gray (N8), very fine-grained; forms beds up to 2 ft. thick, bedding not visible; weathers to slabby ledges.

Limestone, very light gray (N8), dense; forms nodular beds to hackly ledges 1 ft.

thick. Pink bands in claystone due to development of pink cherty spots 64.5

Sandstone (65%) and claystone (35%); sandstone, yellowish gray (5Y8/1), fine- to medium-

grained, moderately sorted; composed of subangular to subrounded clear quartz with common red, green, and white accessory grains; well-cemented with coarse crystals

of calcite; unit is lenticular, beds 1 to 5 ft. thick of wavy laminations and cross-

laminations filling erosion troughs. Weathers to prominent ledges. Claystone, very

light gray (N8), sandy (very fine- to fine-grained); hackly to earthy weathering, forms

narrow slopes between ledges. Locally the sandstone contains dinosaur bones, gastroliths,

and stringers of granule to pebble size reddish brown subangular chert 48.5

LAGUNA section--Continued

Morrison formation--Continued

Brushy Basin member--Continued

Feet

Claystone (70%), sandstone (15%), and limestone (15%). Claystone, variegated, dominantly yellowish gray (5Y8/1), to light greenish gray (5GY8/1) with thin beds of grayish purple (5P4/2) and grayish red purple (5RP4/2) near the base, sandy; in part calcareous; frothy weathering. Sandstone, yellowish gray (5Y8/1), fine- to very fine-grained, well-sorted; composed of subangular clear quartz with abundant pink and white and uncommon green accessory grains (pink probably feldspar); forms lenticular beds 1 to 10 ft. thick pinching out laterally within 300 ft., cross-laminations filling erosion troughs. Limestone, very light gray (N8), weathers white (N9); forms hackly to concretionary rubble-covered slope 58.0

Total Brushy Basin member 372.3

Westwater Canyon member:

Sandstone, yellowish gray (5Y7/2) to grayish yellow (5Y8/4), medium- to coarse-grained with rare grains up to 1/8 in., poorly sorted; composed of subangular clear quartz with common pink feldspar, uncommon red and white accessory grains; firmly cemented, calcareous; medium scale wedging cross-laminations; forms prominent cliff above ledgy slope below. A lenticular bed at base is 1 ft. thick, containing pebbles of red and gray chert and limy claystone. Limonite staining common 56.7

Total Westwater Canyon member 56.7

Recapture member:

Sandstone, clayey, and claystone, sandy, reddish brown (10R3/4) and greenish gray (5GY7/1), fine- to medium-grained, poorly sorted; composed of subrounded stained quartz with uncommon orange and black accessory grains; calcareous; locally stained with limonite. At top of unit is zone of large (1 ft.) nodules of radiating calcite 20.1

LAGUNA section--Continued

Morrison formation--Continued

Recapture member--Continued

	Feet
Total Recapture member	20.1
Total Morrison formation	449.1

Bluff sandstone (part):

Sandstone, clayey, grayish yellow (5Y8/4) to light greenish gray (5GY8/1), medium-grained, fair sorting; composed of subrounded grains of quartz with uncommon black and orange accessory grains; calcareous; bedding obscure. Becomes increasingly clayey upward. Limonite staining common. Weathers to gentle slopes or rounded ledges 29.0

Base of measured section.

NEW MEXICO - VALENCIA COUNTY

ACOMA section, NW-1/4, sec. 8, T. 8 N, R. 7 W.

(Measured by V. L. Freeman, November 1954)

Feet

Top of measured section.

Dakota sandstone:

Not measured or described.

Morrison formation:

Sandstone, clayey, dusky red (5R3/4) (30%) and light greenish gray (5GY8/1) (70%),
 gypsiferous, some limy nodules present. Unit contains minor sandstone beds like
 unit below. Unit forms slightly frothy surface 36.1

Sandstone, yellowish gray (5Y8/1), medium- to fine-grained, well-sorted, subrounded,
 grains of quartz with uncommon red and orange accessory grains; friable,
 calcareous; very lenticular beds with minor beds of argillaceous sandstone like
 below except entirely dusky red; crossbedding is contorted low angle and medium
 scale, filling scour features 7.8

Sandstone, clayey, like top unit but 25% dusky red and 75% light greenish gray 23.7

Sandstone, white (N9), medium- to coarse-grained, conglomeratic, poorly sorted, grains
 of quartz with orange, red, and gray accessory grains, pebbles to 1/2 in. are of chert
 and clay (chert is mostly red with gray and green present); slightly friable, calcareous;
 crossbedding is low angle and medium scale, filling scour features 3.3

Sandstone, clayey, dusky red (5R3/4) and light greenish gray (5GY8/1) in about equal
 amounts, fine-grained, poorly sorted, some limy nodules, minor amounts of sandy
 claystone and sandstone like below, forms slightly frothy surface 65.4

ACOMA section -- Continued

Morrison formation--Continued

	Feet
Sandstone, yellowish gray (5Y8/1), medium-grained, well-sorted, subrounded, grains of quartz with uncommon red and orange accessory grains; friable, calcareous; very lenticular beds with some argillaceous sandstone like below near center of unit; Contorted crossbedding is low angle and medium scale, filling scour features	12.0
Sandstone, clayey, dusky red (5R3/4), fine-grained, poorly sorted; forms slightly frothy surface	7.0
Note: At least lowest unit is probably equivalent to Recapture member	---
Total Morrison formation	155.3

Bluff sandstone (part):

Sandstone, pale yellowish green (10GY8/2), fine-grained, well-sorted, subrounded grains of quartz with rare orange and red accessory grains; friable, some calcareous cement, some unknown white cement; unit weathers into rounded knobs; bedding not visible	Not measured
Base of section.	

NEW MEXICO - SANDOVAL COUNTY

CUCHILLO ARROYO section, sec. 36, T. 17 N., R. 1 W.

(Measured by L. C. Craig and V. L. Freeman, 1950)

	Feet
Top of measured section .	
Morrison formation (part):	
Brushy Basin member (part):	
Sandstone, very pale orange (10YR8/2) fine-grained, subangular, grains of clear quartz with uncommon orange and black accessory grains; hard, siliceous cement; lenticular strata, forms prominent local capping ledge	2.5

CUCHILLO ARROYO section--Continued

Morrison formation--Continued

Brushy Basin member--Continued

	Feet
Claystone, light greenish gray (5GY8/1), pale yellowish brown (10YR6/2), and pale reddish brown (10R5/4), silty to medium-grained sandy, with common 1 in. to 1 ft. beds of pale reddish brown (10R5/4) and greenish gray (5G6/1) silicified claystone, several light gray (N7) dense lenticular limestones; weathers to pastel green and pink; forms earthy to frothy slope	58.3
Sandstone, light greenish gray (5GY8/1) to yellowish gray (5Y8/1), fine-grained, sub-angular, well-sorted, grains of clear quartz with common orange, green, and black accessory grains; massive, forms resistant ledge, is local highly lenticular unit	2.4

CUCHILLO ARROYO section-- Continued

Morrison formation--Continued

Brushy Basin member-- Continued

	Feet
Claystone, light greenish gray (5G8/1) to light gray (N7) with minor pale reddish brown (10R5/4) and pale yellowish brown (10YR4/2) at top, silty to very fine-grained sandy; weathers to earthy light greenish gray slope with a few pale reddish brown bands at top; one 6 in. lens of pale reddish brown silicified claystone or limestone near top	42.1
Total measured Brushy Basin member	105.3
Total Brushy Basin member <u>2</u> /	180.0

Westwater Canyon member:

Sandstone, light olive gray (5Y5/2) to yellowish gray (5Y8/1) to light greenish gray (5GY8/1), very fine-grained at top and coarse-grained at bottom, predominantly medium-grained, subangular to subrounded, grains of clear quartz with rare orange and black accessory grains; medium scale cross-laminated, scour bedding. Note: Top four Westwater sandstone units appear transitional to Brushy Basin member	22.5
Claystone, pale grayish yellow (5Y9/4) to pale greenish gray (5G6/1), slightly silty to medium-grained sandy; weathers to earthy slope	5.4
Sandstone, grayish orange (10YR7/4) to yellowish gray (5Y8/1), very fine-grained to medium-grained, subangular to rounded, poorly sorted, grains of clear quartz with rare orange and gray to black accessory grains; weakly cemented with streaks and bands of firm calcareous cement; medium scale cross-lamination indicated, scour bedding; forms ledgy slope	31.8

2/ Measured by E. H. Baltz, Jr., personal communication.

CUCHILLO:ARROYO section--Continued

Morrison formation--Continued

Westwater Canyon member--Continued

	Feet
Claystone, greenish gray (5GY6/1), silty to slightly fine-grained sandy; weathers to earthy sandy slope, abundant very light gray (N8) dense to very fine-grained limestone nodules on surface	8.6
Sandstone, pale yellowish orange (10YR8/6) to yellowish gray (5Y8/1) to white, fine- to medium-grained, subangular to subrounded, moderately sorted, grains of clear quartz with uncommon orange and white accessory grains, locally has specks of unknown white cement; medium scale cross-laminated, channeling; lateral to section contains thin lenses of greenish claystone	85.5
Claystone, grayish red (10R4/2) and light greenish gray (5G 8/1) with minor very fine- to fine-grained sandstone lenses	2.5
Sandstone, pale yellowish orange (10YR8/6) to yellowish gray (5Y8/1) to white (N9), fine- to medium-grained, subangular to subrounded, moderately sorted, grains of clear quartz with uncommon orange and white accessory grains, locally has specks of unknown white cement; medium scale cross-laminated, channeling	15.0
Total Westwater Canyon member	171.3

Recapture member:

Claystone, and sandstone (20%). Claystone, very dusky red (10R2/2), silty to slightly fine-grained sandy, structure partly masked, some thin irregular parallel beds; sandstone, light greenish gray (5GY8/1) to yellowish gray (5Y8/1), fine-grained, subangular, moderately to poorly sorted, some interstitial clay, grains of clear quartz with uncommon orange and black and minor green accessory grains; in structureless beds 6 in. to 3.5 ft. thick; unit forms steep earthy slopes except under overlying cliff where it stands vertical	25.5
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CUCHILLO ARROYO section--Continued

Morrison formation --Continued

Recapture member--Continued

	Feet
Sandstone and claystone, grayish orange pink (10R8/2) and very minor greenish gray (5GY6/1), fine- to medium-grained, subangular to rounded, moderately sorted, grains of clear quartz with abundant orange and black and rare green accessory grains; medium scale cross -lamination is indistinct; claystone, very dusky red (10R2/2) to grayish red (10R4/2), silty to slightly sandy, structureless to thin parallel bedded; unit weathers to steep ledgy slope of white and yellowish gray with grayish red bands	94.0
Sandstone and claystone (25%), sandstone, grayish orange pink (10R8/2), very fine- to medium-grained, moderately sorted, subangular to subrounded, grains of clear quartz with common black and orange accessory grains; several biotite flakes noted; medium scale cross-laminations indistinct, locally channeling; claystone, very dusky red (10R2/2) to grayish red (10R4/2), very slightly sandy up to fine-grained, finely micaceous, contains some thin sandstone beds, light greenish gray (5GY8/1) to grayish red (10R4/2), very fine- to fine-grained, subangular, moderately sorted, grains of clear quartz with abundant orange and black accessory grains; structureless; unit as whole weathers to pale red and grayish red ledgy slope	96.5
Sandstone, white to moderate orange pink (5YR8/4), very fine- to medium-grained, moderately sorted, subangular to subrounded, grains of clear quartz with abundant orange and common black and rare green accessory grains; medium scale cross-laminations indicated; unit weathers to sandy ledgy slope	13.4

CUCHILLO ARROYO section--Continued

Morrison formation--Continued

Recapture member--Continued

Feet

Claystone, very dusky red (10R2/2), grayish purple (5P4/2) and grayish red (10R4/2);	
very fine- to medium-grained sandy; sandstone, light greenish gray (5G8/1) mottled	
grayish red (5R4/2), very fine- to fine-grained, rare medium grains, interstitial clay	
common, moderately to poorly sorted, subangular to rounded, grains of clear quartz	
with common orange, red, and black accessory grains; unit weathers to steep earthy	
slope	47.0
Total Recapture member	276.4
Base of measured section,	

Summerville formation (part):

Claystone and sandstone; claystone, dark reddish brown (10R3/4) to pale reddish brown	
(10R5/4), pure to very sandy, very fine- to fine-grained, earthy weathering; sandstone,	
pale reddish brown (10R5/4) to grayish orange pink (10R8/2), very fine- to fine-grained,	
moderately sorted, subangular, weak to firm calcareous cement, grains of clear quartz	
with common black and orange accessory grains; unit weathers to earthy slope. .	
	Not measured

NEW MEXICO - MCKINLEY COUNTY

HAYSTACK BUTTE section, sec. 13, T. 13 N., R. 11 W.

(Measured by L. S. Hilpert and V. L. Freeman, August 1954)

Feet

Top of measured section .

Dakota sandstone (part):

Sandstone, light reddish orange (10R7/6), medium-grained, well-sorted, subrounded,
 grains of quartz with some white chert grains; friable, quartz overgrowths 40.0

Shale, carbonaceous. Some interbedded clayey sandstone, grayish red (5R4/2), medium-
 grained, poorly sorted, angular to subrounded 17.8

Morrison formation:

Brushy Basin member:

Poorly exposed. Local outcrops of claystone, silty and sandy, light greenish gray (5GY8/1);
 and sandstone, pale yellowish brown (10YR6/2), medium-grained, poorly sorted,
 subangular to subrounded, grains of quartz with red and white accessory grains;
 friable, calcareous cement and specks of white unknown cement 67.2

Sandstone, slightly conglomeratic, pale yellowish brown (10YR6/2) with local greenish
 gray (5GY6/1), medium- to coarse-grained, poorly sorted, subangular to subrounded,
 grains of quartz with red and white accessory grains, granules and pebbles (to 3/4 in.);
 friable, calcareous cement and specks of unknown white cement; crossbedding is
 medium scale and low angle filling shallow erosional troughs 2.7

Claystone, silty and sandy, very dusky red (10R2/2) and greenish gray (5GY6/1) 9.6

Sandstone, like second unit below 23.2

HAYSTACK BUTTE section--Continued

Morrison formation--Continued

Brushy Basin member--Continued

	Feet
Sandstone (at base) and claystone, silty; sandstone, very pale orange (10YR8/2), fine-grained, poorly sorted, subrounded, grains of quartz with orange, black, and white accessory grains, possibly some silica cement; claystone, dusky red (10R3/2)	6.0
Sandstone, pale yellowish brown (10YR6/2), very coarse-grained at base grading upward to medium-grained at top, poorly sorted, subangular to subrounded, grains of quartz with red and white accessory grains; very friable, calcareous near base, specks (1 to 3mm across) of unknown white cement scattered throughout; crossbedding is medium scale and low angle filling shallow erosional troughs	18.1
Claystone, silty, pale reddish brown (10R5/4), mottled with yellowish gray (5Y8/1)	24.5
Total Brushy Basin member	151.3

Westwater Canyon member:

Sandstone, grayish red (10R5/2) to light brown (5YR7/4) in lower part and grayish orange (10YR7/2) with some limonite stain near top, poorly sorted, subrounded to rounded, grains of quartz with white, black, and orange accessory grains; locally calcareous in lower part; crossbedding is large scale and low angle filling shallow erosional troughs; mud pods and partings near base; this unit forms a prominent cliff	106.0
Total Westwater Canyon member	106.0

Recapture member:

Sandstone, very clayey, dark reddish brown (10R3/4) and light greenish gray (5GY8/1), fine-grained, poorly sorted with some coarse grains, subrounded, grains of quartz with orange, red, and black accessory grains; very calcareous near middle	2.5
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HAYSTACK BUTTE section--Continued

Morrison formation--Continued

Recapture member--Continued

	Feet
Sandstone, yellowish gray (5Y8/1) and light olive gray (5Y6/1), fine-grained, well-sorted, subrounded, grains of quartz with orange and black accessory grains; slightly calcareous, locally clayey; bedding obscure	5.5
Sandstone, very clayey, dark reddish brown (10R3/4) to grayish red (5R5/2) with interbeds of pale olive (10Y6/2) near top, medium-grained, poorly sorted, subrounded, grains of quartz with orange and black accessory grains; calcareous with nodules near top. . .	18.0
Sandstone, very light greenish gray (5GY9/1) to light pinkish gray (5YR9/1), fine- to medium-grained, poorly sorted, subrounded, grains of quartz with orange accessory grains; friable, calcareous; bedding obscure	11.2
Sandstone, very clayey, dark reddish brown (10R3/4), fine-grained, poorly sorted, subrounded	10.3
Sandstone, light yellowish gray (5Y9/1), medium- to coarse-grained, moderately sorted, subrounded to rounded, grains of quartz with white, orange, and black accessory grains; friable, slightly calcareous; at base are granules and pebbles (to 1/2 in.) of red, black, and green chert; bedding mostly obscure, some crossbedding is medium scale, low angle, and some is straight in tabular sets	8.9
Sandstone (75%) and claystone, sandy; sandstone, yellowish gray (5Y8/1) and pinkish gray (5YR8/1), fine-grained, moderately sorted, rounded, grains of quartz with orange and black accessory grains, locally green clay pods in sandstone at base, locally calcareous; claystone, pale yellowish green (10GY7/2) with mottling of dark reddish brown (10R3/4)	15.7

HAYSTACK BUTTE section--Continued

Morrison formation--Continued

Recapture member--Continued

	Feet
Claystone, sandy, like second unit below, contains some thin sandstone beds near top . . .	6.9
Sandstone, light yellowish gray (5Y9/1), medium-grained, moderately sorted, subrounded, grains of quartz with orange, red, and black accessory grains; very friable, calcareous especially near top and base; rare scattered pebbles near base; bedding obscure	5.8
Claystone, sandy, mottled dark grayish red (10R3/2) and greenish gray (5GY7/1), calcareous. Near middle of unit is 8 in. bed of sandstone, greenish gray (5GY7/1), very fine-grained; friable, calcareous; thin parallel laminations	7.0
Sandstone, pale red (10R6/2) and pinkish gray (5YR8/1), medium-grained with scattered granules and pebbles (to 1 in.) locally concentrated along laminae; moderately to poorly sorted, rounded; grains of quartz with orange, red, black, and green accessory grains; very friable, calcareous; claystone parting about 7-1/2 ft. above base; bedding mostly parallel but near base is cross-bedding of medium to large scale and low angle that fills shallow erosional troughs	44.4
Total Recapture member	133.2

Bluff sandstone:

Sandstone, moderate orange pink (10R7/4) to light brown (5YR7/4), fine-grained, well- sorted, subrounded, grains of quartz with orange accessory grains; friable, calcareous; crossbedding is large scale and low angle in tabular sets; forms nearly vertical cliff	Not measured
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Base of section .

NEW MEXICO - BERNALILLO COUNTY

NORTH OF CAÑONCITO section, E1/2, sec. 34, T. 11 N., R. 3 W.

(Measured by V. L. Freeman, October 1954)

Feet

Top of measured section.

Dakota sandstone:

Not measured or described.

Morrison formation:

Brushy Basin member:

Claystone, sandy, light greenish gray (5G8/1), minor amounts of sandstone and limy nodules,

forms frothy surface. Poorly exposed, especially near top 176.0

Sandstone, yellowish gray (5Y8/1), medium-grained, moderately sorted, subrounded,

grains of clay coated quartz with orange, black, and white accessory grains, quartz,

clay, and calcite cement; bedding indistinct but in part is crossbedded on medium

scale 11.7

Claystone, sandy and sandstone, clayey, yellowish gray (5Y8/1) to light brownish gray

(5YR6/1) with minor greenish tint; some limy nodules and chert; forms slightly

frothy surface. 52.6

Total Brushy Basin member 240.3

Gradational contact,

Recapture member (probably includes equivalents to Westwater Canyon member):

Sandstone, partly clayey, yellowish gray (5Y8/1) with limonite stains near base, fine-

medium-grained, moderately sorted; friable, calcareous especially near base; bedding

not visible 14.5

NORTH OF CAÑONCITO section--Continued

Morrison formation--Continued

	Feet
Claystone, very sandy (to medium-grained), grayish red (10R4/2), calcareous. Unit	
contains one thin hard green sandstone bed; forms slightly frothy surface	24.2
Sandstone, moderate orange pink (5YR8/4) to yellowish gray (5Y8/1), medium-grained,	
poorly sorted, rounded, grains of quartz with uncommon black and orange accessory	
grains; friable, calcareous cement and uncommon specks of unknown white cement;	
crossbedding is small to medium scale	10.1
Claystone, very sandy and sandstone, clayey; grayish red (10R4/2), calcareous; sandstone	
in thin irregular beds totaling about half a unit	20.0
Sandstone, yellowish gray (5Y8/1), medium-grained, moderately sorted, rounded, grains	
of quartz with common black, orange, red, and white accessory grains; alternating	
hard and friable zones, calcite cement; bedding not visible	5.4
Claystone, very sandy, like second unit below	10.5
Sandstone, yellowish gray (5Y8/1), fine-grained, poorly sorted, rounded, grains of quartz	
with uncommon orange, red, black, and white accessory grains; slightly friable,	
calcareous; structureless; common limonite staining. Unit grades into unit above .	18.0
Claystone, very sandy (to medium-grained), grayish red (10R4/2), calcareous, several	
irregular thin beds of sandstone	12.6
Total Recapture member and probable equivalents of Westwater Canyon member .	115.3
Base of measured section.	
Bluff sandstone (part):	
Sandstone, grayish yellow (5Y7/4), fine-grained, well-sorted, rounded, grains of quartz :	
with black, white, and orange accessory grains; friable; bedding indistinct but in	
part is extremely large scale crossbedding	Not measured

NEW MEXICO - VALENCIA COUNTY

RED BLUFF section, W1/2, sec. 3, T. 12 N., R. 9 W.

(Measured by V. L. Freeman and L. S. Hilpert, August 1954)

Feet

Top of measured section

Dakota sandstone (part):

Sandstone, very pale orange (10YR8/2), to dark yellowish orange (10YR6/6), the yellow coloring caused by limonite staining generally along bedding, medium-grained, poorly sorted with local scattered granules and pebbles of red and black chert and vein quartz, subangular to rounded, grains of quartz with rare chert and white accessory grains; abundant quartz overgrowths; parallel bedded with some tabular crossbedding 49.0

Morrison formation:

Brushy Basin member:

Claystone and sandstone, clayey, poorly exposed; greenish gray (5GY6/1) at base and pale olive (10Y6/2); local calcareous thin-bedded sandstone lenses, greenish gray (5GY6/1), fine-grained 88.0

Sandstone, pale yellowish brown (10YR7/2), medium- to coarse-grained, poorly sorted with local granules and small pebbles, subangular to rounded, grains of quartz with uncommon orange and black accessory grains; crystal calcite cement at top and specks of unknown white cement throughout; cross-lamination are medium scale and low angle filling shallow erosion troughs 14.4

Mostly covered; some claystone, yellowish gray (5Y8/1) and light greenish gray (5GY8/1), free of sand grains, some limy nodules, some seams of gypsum 42.6

RED BLUFF section--Continued**Morrison formation--Continued****Brushy Basin member--Continued**

	Feet
Sandstone, yellowish gray (5Y8/1), medium-grained, poorly sorted, rounded grains of quartz with white, black, green, and orange accessory grains; friable, calcareous; forms surface coated by small nodules	4.0
Claystone, slightly sandy, grayish yellow green (5GY7/2) and light grayish red (10R5/2) in lower part, common limy nodules	10.6
Total Brushy Basin member	159.2

Westwater Canyon member:

Sandstone, grayish orange (10YR7/4) with widespread limonite specks, medium- to coarse- grained, moderately to poorly sorted with scattered granules, subrounded, grains of quartz with common white (kaolin?) and rare black (chert?) accessory grains; friable, local crystal calcite cement; cross-laminations are medium scale and low angle between planar erosion surfaces. Locally claystone, pale yellowish green (10GY7/2) occurs near the base in irregular pods	62.2
Total Westwater Canyon member	62.2

Recapture member:

Sandstone, clayey and some claystone, sandy, dusky red purple (5RP3/2) and greenish gray (5GY6/1), sandstone in fine-grained, claystone locally contains limy nodules; unit forms mostly covered slope	25.9
Sandstone, light yellowish gray (5Y9/1), fine- to coarse-grained, local conglomeratic lenses with pebbles dominantly of chert, moderately to poorly sorted, subrounded, grains of quartz with white, orange and black accessory grains; crystal calcite cement; crossbedding filling scours	7.4

RED BLUFF section--Continued

Morrison formation--Continued

Westwater Canyon member--Continued

	Feet
Sandstone, clayey and claystone, sandy, mostly light greenish gray (5GY8/1) and brownish gray (5YR4/1) with some grayish red purple (5RP4/2) and dusky yellow (5Y6/4); sandstone is fine-grained and poorly sorted; local limy nodules.	3.0
Sandstone, light yellowish gray (5Y9/1), medium-grained, poorly sorted, rounded, grains of quartz with white and orange accessory grains, scattered granules and green clay chips; friable, locally calcareous; bedding obscure; weathers to rounded ledge . . .	9.0
Sandstone, clayey, very dusky red purple (5RP2/2), very fine- to fine-grained, moderately sorted, grains of quartz with black and orange accessory grains; local small limy nodules. Unit contains local thin beds of sandstone, greenish gray (10GY5/2); hard, clay cement	7.5
Sandstone, light yellowish gray (5Y9/1) and very light greenish gray (5GY9/1), fine- to medium-grained, poorly sorted, subrounded, grains of quartz with white, orange, red, green, and black accessory grains; friable; crossbedding is small to medium scale and low angle in tabular sets between planar erosion surfaces	8.5
Sandstone, lenticular with thin irregular lenses and pods of claystone; claystone, dark reddish brown (10R3/4) mottled light greenish gray (5GY8/1); sandstone, light pinkish gray (5YR9/1), medium- to coarse-grained with scattered granules, poorly sorted, subrounded to rounded, grains of quartz with orange and black accessory grains; friable, calcareous; crossbedding is small scale and low angle in wedge-shaped sets . . .	3.9

RED BLUFF section--Continued

Morrison formation--Continued

Recapture member--Continued

	Feet
Sandstone, light pinkish gray (5YR9/1), medium- to coarse-grained, with rare granules, poorly sorted, subrounded to rounded, grains of quartz and chert with white and orange accessory grains; friable; in part is parallel bedded and in part is crossbedded, medium scale, low angle. This unit fills a channel in underlying unit that is 2 to 4 ft. deep and about 20 ft. wide	11.0
Sandstone, slightly clayey, greenish gray (5GY6/1), medium-grained, moderately sorted, rounded, grains of quartz with uncommon orange and red and rare black accessory grains; forms slope	1.3
Claystone, slightly silty, very dusky red (10R2/3); some limy nodules and gypsum; forms rounded slope	4.3
Sandstone, slightly clayey, pale olive (10Y3/2) with some limonite stains, fine- to medium-grained, moderately sorted, rounded, grains of quartz plus common orange and rare black accessory grains; very friable; forms slope. Unit appears gradational with Bluff sandstone	8.8
Total Recapture member	90.6
Total Morrison formation	312.4
Bluff sandstone (part):	
Sandstone, grayish yellow (5Y8/4), fine- to medium-grained; very friable, calcareous concretions locally present; cross laminations are medium to large scale and high angle in wedge shaped sets	Not measured
Base of section	

NEW MEXICO - VALENCIA COUNTY

SHEEP CAMP section, S1/2 sec. 2, T. 8 N., R. 6 W.

(Measured by V. L. Freeman, September 1954)

Feet

Top of measured section.

Dakota sandstone (part);

Sandstone, like basal Dakota unit, two silicified 6 in. bands, also a few very thin

carbonaceous claystone partings 15.0

Claystone, carbonaceous, sandy. Along strike unit becomes sandstone like below with

very thin partings of carbonaceous claystone. Unit forms re-entrant in cliff . . . 1.0

Sandstone, light yellow (5Y8/6), medium-grained, poorly sorted, granules common,

rounded, grains of clay coated quartz with white (chert?) accessory grains; one 6 in.

band is highly silicified and white; very thin crossbedding is medium scale and low

angle. Plant remains present 4.9

Morrison formation:

Claystone, slightly fine-grained sandy, pale olive (10Y6/2) and minor grayish red

purple; forms slightly frothy surface 43.5

Sandstone, white (N9), medium-grained, well- to moderately sorted, subrounded,

grains of quartz with orange and white accessory grains; slightly friable, calcareous

cement; indistinct crossbedding is medium scale and low angle 6.0

Claystone, like second unit below with two thin beds of sandstone, like below,

that total 3 ft. 25.7

SHEEP CAMP section--Continued

Morrison formation--Continued

	Feet
Sandstone, white (N9), medium-grained, well- to moderately sorted, subrounded, grains of quartz with orange and white accessory grains; slightly friable, calcareous cement; indistinct crossbedding is medium scale and low angle	4.6
Claystone, slightly fine-grained sandy, pale olive (10Y6/2) and minor grayish red purple; forms slightly frothy surface	13.0
Sandstone, very light greenish gray (5GY8/1), fine- to medium-grained, well- to moderately sorted, subrounded, grains of quartz with orange and white accessory grains; slightly friable, calcareous cement; crossbedding is medium scale and low angle. Uncommon limy nodules. Unit is lenticular and interfingers with unit above . .	8.5
Sandstone, clayey, very dusky red (between 5RP2/2 and 10R2/2) and light greenish gray (5GY8/1) in about equal amounts in alternating bands, medium-grained, moderately sorted, subrounded, grains of quartz and rare orange accessory grains; hard when fresh; unit forms soft slope. Laterally unit contains lens like unit above .	16.8
Sandstone, clayey, dark reddish brown (10R3/5), fine-grained, moderately sorted, subrounded, grains of stained quartz with rare black accessory grains; hard when fresh; unit forms soft slope. Unit grades into Bluff sandstone and locally interfingers with Bluff	3.7
Note: Lower two units of Morrison probably are equivalent to Recapture member and remainder probably equivalent to Brushy Basin member	----
Total Morrison formation	121.8

SHEEP CAMP section--Continued

Morrison formation--Continued

Feet

Bluff Sandstone (part):

Sandstone, light greenish yellow (10Y7/2) slightly lighter near top, medium- and fine-grained in gradationally alternating 6 in. beds, well to moderately sorted, subrounded to rounded, grains of green clay coated quartz with common white chert and rare orange accessory grains; friable, zones of heavy limonite cement. Poorly defined parallel bedding underlain by crossbedding of extremely large scale and low angle Not measured

Base of section.

NEW MEXICO - VALENCIA COUNTY

WEST MESA GIGANTE section (composite).

(Measured by V. L. Freeman, September, October 1954)

Section A., sec. 10, T. 10 N., R. 4 W.

Top of measured section

Dakota sandstone:

Not measured. Sandstone, conglomeratic, with minor carbonaceous shale. Siliceous cement.

Morrison formation:

Brushy Basin member:

Sandstone, yellowish gray (5Y8/1) to white (N9), medium-grained, well to poorly sorted, subrounded to subangular, grains of clay coated quartz with rare pink and black accessory grains, green clay chips locally abundant but usually rare; friable, some calcareous cement and specks of white unknown cement; crossbedding is medium scale and low angle filling shallow erosion troughs. This is "Jackpile" sandstone . . . 90.9

WEST MESA GIGANTE section A --Continued

Morrison formation--Continued

Brushy Basin member--Continued

	Feet
Claystone, silty and siltstone, clayey, light greenish gray (5GY8/1) and minor grayish red (10R4/2), limy nodules common. Near top is 2 ft. bed of sandstone, clayey, light grayish green (5GY6/2)	105.7
Sandstone, yellowish gray (5Y8/1), medium-grained, poorly sorted, subrounded to sub-angular, grains of clay coated quartz with orange, red, black, and rare green accessory grains; granules and pebbles (to 1/2 in.) scattered in sandstone, include feldspar; crossbedding is medium scale and low angle, filling shallow erosion troughs .	20.0
Claystone, silty; siltstone and very fine sandstone, both very clayey; all light greenish gray (5G8/1), some hard calcareous beds, weathers to frothy surface	71.7
Sandstone, very pale orange (10YR8/2) to dark yellowish brown (10YR3/4), medium-grained, moderately sorted, grains of quartz with green, orange, red, and black accessory grains; hard; crossbedding is medium scale and low angle. Three beds with clay chips at base of each	3.0
Siltstone and very fine sandstone; both clayey, pinkish gray (5YR8/1) and light greenish gray (5GY8/1), calcareous; also claystone, silty, light greenish gray (5GY8/1) and minor pale purple (5P6/2), hard, calcareous; some units weather to frothy surface . .	81.2
Total Brushy Basin member	372.5

WEST MESA GIGANTE section--Continued

Section B, SW-1/4 of sec. 23, T. 10 N., R. 4 W.

Morrison formation--Continued

Westwater Canyon member:

	Feet
Sandstone, very pale orange (10YR8/2) to dusky yellow (5Y6/4), medium- to coarse-grained, poorly to moderately sorted, subrounded to angular, grains of quartz and feldspar (angular and up to granules in size) with common red and white (chert?) accessory grains; some beds clayey; friable except for local crystal calcite cement.	
Indistinct crossbedding	31.1
Sandstone, like purple part of third unit below	1.5
Sandstone (75%) and claystone with limy nodules (25%); sandstone, very pale orange (10YR8/2), medium- to coarse-grained, moderately sorted, rounded to subrounded, grains of quartz and feldspar with common red and white and uncommon green and gray accessory grains; friable, calcareous, locally crystal calcite cement; crossbedding is small to medium scale, low angle, lenticular type; claystone like below but pale purple (5P7/2) in color and with large (1 ft.) nodules that form bed	19.5
Total Westwater Canyon member	52.1

On Section A where base is not exposed Westwater Canyon is 62 ft. thick.

Recapture member:

Claystone, slightly fine-grained sandy, light greenish gray (5G8/1) with purplish tints locally; limy nodular beds total 2.0 ft. Claystone is slightly calcareous	8.3
Sandstone, very clayey, pale yellowish green (10GY7/2) in middle 1/3, rest is grayish red purple (5RP4/2). Medium-grained, poorly sorted, rounded, grains of quartz with common orange and red and rare black and white accessory grains. Purple part is calcareous. Bedding obscure	5.8

WEST MESA GIGANTE section B--Continued

Morrison formation--Continued

Recapture member--Continued

Feet

Claystone, very sandy (fine-grained) (50%) and sandstone (50%): claystone, reddish

brown (10R4/4), slightly calcareous but not containing limy nodules here;

sandstone, yellowish gray, medium-grained, moderately sorted, rounded, grains of quartz with uncommon orange, black, and red accessory grains; bedding obscure.

Sandstone and claystone thickly (2 to 3 ft.) interbedded. Claystone beds weather

to slightly frothy surface 31.6

Total Recapture member 45.7

Base of measured section.

Bluff sandstone (part):

Sandstone, grayish yellow (5Y8/4) to moderate yellow (5Y7/6), medium-grained, well

to moderately sorted, rounded grains of quartz with black, orange, and white accessory

grains; friable, local crystal calcite cement. Crossbedding is large scale and

poorly defined Not measured