Clarence Dutton's stratigraphy of west-central New Mexico

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CLARENCE DUTTON'S STRATIGRAPHY OF WEST-CENTRAL NEW MEXICO

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Abstract.—In 1885, Clarence Dutton published a stratigraphy of the thick (~ 3 km), essentially homoclinal section of upper Paleozoic, Mesozoic and Paleogene strata exposed on the northern flank of the Zuni Mountains in west-central New Mexico. Dutton's stratigraphy of most of the section was conservative, in that he assigned the Paleozoic, Cretaceous and Paleogene strata to units already named elsewhere on the Colorado Plateau. This part of Dutton's stratigraphy also contained several oversights, inaccuracies and miscorrelations, and it had little effect on subsequent understanding of the Phanerozoic stratigraphic section in west-central New Mexico. However, Dutton did introduce two new stratigraphic names for the Triassic-Jurassic rocks, Wingate Sandstones and Zuni Sandstones, and these units, though much misunderstood by later workers, continue to be recognized in west-central New Mexico. It is the recognition of the Wingate and Zuni sandstones that represents Dutton's substantive and lasting contribution to the regional stratigraphy of west-central New Mexico.

INTRODUCTION

In 1853, Jules Marcou traversed west-central New Mexico, from near Mt. Taylor to Zuni Pueblo. Marcou's (1858) geologic map (at a scale of about 1: 5,000,000), and his brief descriptions, are the first published geological observations on west-central New Mexico (Lucas, 2001).

Newberry (1861, 1876) reported on some geological observations in west-central New Mexico made as a member of the Ives Expedition (1857-1858) and of the Macomb Expedition (1859). In his traverse from Fort Defiance to Santa Fe, Newberry (1861) assigned limestones with brachiopods on the north slope of the Zuni Mountains to the Carboniferous. He termed overlying red-bed sandstones and mudstones the "marl series" of uncertain age, overlain by Cretaceous strata. In Newberry (1876), he assigned the "marl series" a Triassic age, thus arriving at the same stratigraphic section on the north flank of the Zuni Mountains as did Howell and Gilbert, who followed.

As an outgrowth of the 1872 and 1873 Wheeler Survey of the U. S. Army, both Howell (1875) and Gilbert (1875) offered some brief stratigraphic observations and generalized maps and cross sections on the geology of west-central New Mexico. Their stratigraphic scheme recognized Carboniferous, Triassic and Cretaceous strata, and Howell (1875, p. 283) noted "the Zuni Mountains, which are composed of Carboniferous rocks with a crystalline nucleus, exposed near their southeastern extremity, while the range is wholly surrounded by Trias cliffs."

The next published work on the geology of west-central New Mexico was Clarence Dutton's (1885) article that appeared in the Sixth Annual Report of the U. S. Geological Survey. Dutton's work included a geological map of west-central New Mexico at a scale of 1:640,000 (Fig. 1), structural (Fig. 2) and stratigraphic sections (Fig. 3), a series of remarkable woodcuts illustrating outcrops and other geologic (especially volcanic) features and a systematic text describing the geology of an area of approximately 20,000 km^2. Dutton's map and text make it clear that he understood that there is a thick, essentially homoclinal section of Paleozoic, Mesozoic and Paleogene sedimentary rocks about 3 km thick exposed along the northern dip slope of the Zuni Mountains (Fig. 1). Dutton (1885) created a stratigraphy for these sedimentary rocks (Fig. 3), and my purpose here is to review and evaluate that stratigraphy.

DUTTON'S STRATIGRAPHY

Paleozoic

"Carboniferous"

Dutton (1885, p. 132) noted that in west-central New Mexico "the lower Carboniferous, Devonian, Silurian, and Cambrian do not occur, and the base of the upper Carboniferous is seen to rest upon the granites and schists of the Archean age." Thus, the oldest Phanerozoic strata (they overlie Proterozoic basement: Mawer and Bauer, 1989) recognized by Dutton in west-central New Mexico were assigned by him to the Upper Carboniferous, and he termed them Aubrey Group. Gilbert (1875) had named the Aubrey Group for upper Paleozoic sandstones and limestones in Arizona that Darton (1910) later assigned to the Permian Supai, Coconino and Kaibab formations.

Dutton noted the then-perceived division of the Aubrey into a lower, red-sandstone-dominated interval (Supai Formation of later usage) and an upper, yellowish-brown siliceous sandstone interval (principally Coconino Sandstone of later usage). In west-central New Mexico, Dutton (1885, p. 133) listed the Aubrey Group thickness as about 1200 ft (366 m), and he described (p. 132) the lower part as "bright red sandstones throughout, deposited usually in rather thick, and less frequently in moderately thin, layers….they are very fine grained, without traces of conglomerate or coarse shingle or gravels." Dutton (1885, p. 133) went on to describe the upper Aubrey as sandstones that are:

> yellowish-brown, and the cement, instead of being calcareous, is siliceous, in fact a regular chert. These sandstones in their final induration, seem to have been subjected to some process by which soluble silica has been deposited within them in great quantities, whether by the solution of the quartz of the granules of which the sediment was originally composed… .These sandstones are often conspicuously cross-bedded….and intercalated with them are three or four thick beds of pure limestone, containing an abundance of fossils of many and characteristic species.

Clearly, Dutton's "lower Aubrey," 800 ft (244 m) thick, encompasses strata now referred to the Lower Permian Abo Formation, and his 400-ft (122 m) thick "upper Aubrey" is the Lower Permian Glorieta and San Andres formations. It is not clear, how-

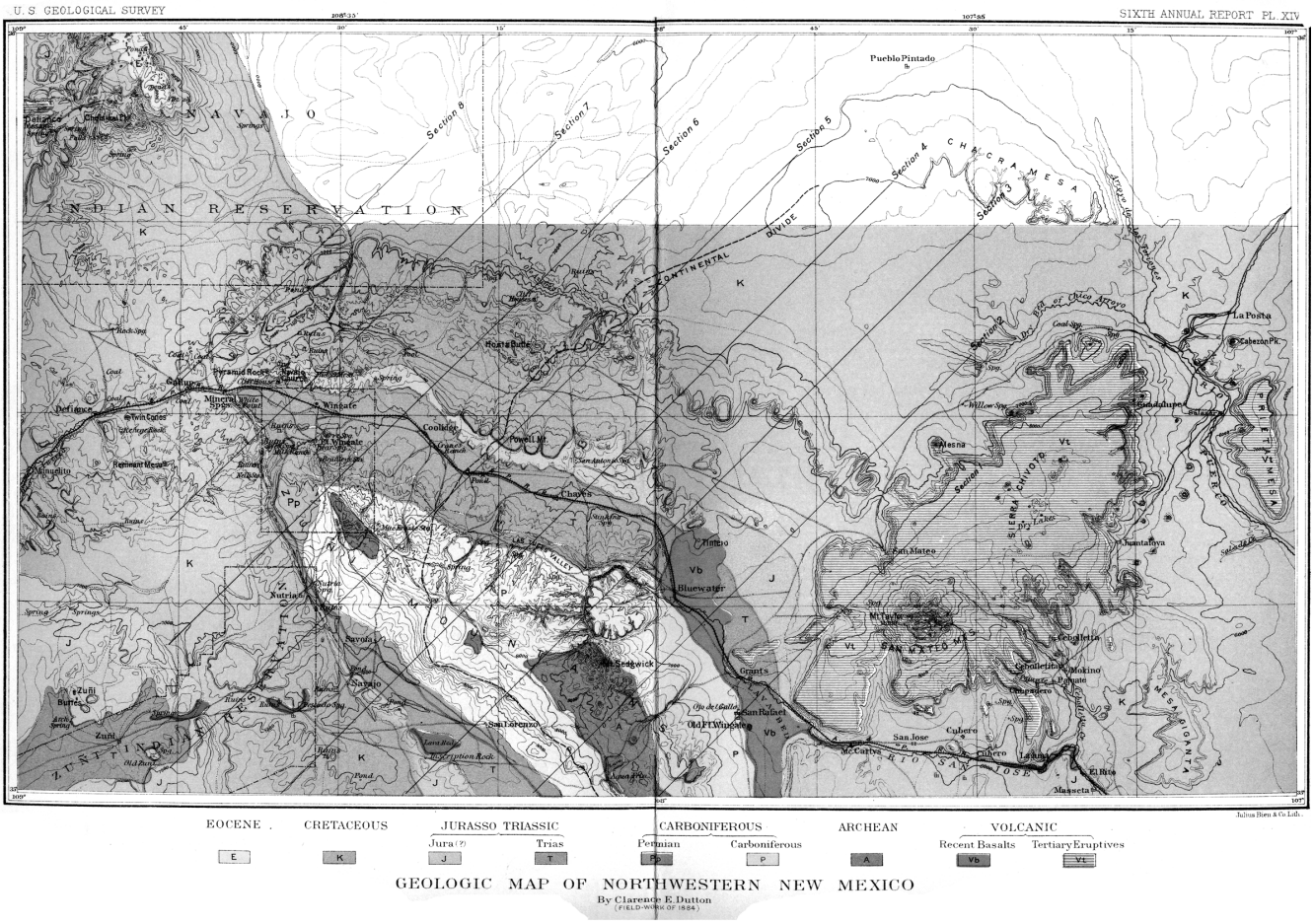

FIGURE 1. Dutton's (1885, pl. 14) geological map of west-central New Mexico.

ever, where the Yeso Formation (between the Abo and Glorieta) strata fit in Dutton's section (see below). Thus, Dutton's "Aubrey Group" in the Zuni Mountains is now known to be Permian, not Carboniferous in age, and only part of it is actually correlative to Gilbert's (1875) Aubrey Group in Arizona.

Dutton (1885) did not recognize a thin (<10 m thick) and patchy interval of Pennsylvanian marine strata that are at the base of the Phanerozoic section in the Zuni Mountains (Armstrong et al., 1994). The Abo Formation in the Zuni Mountains is about 200 m thick and consists mostly of red-bed mudstones but also contains significant beds of sandstone, especially in its upper part (Colpitts, 1989). The sandstone beds evidently escaped Dutton's observation, but his thickness estimate of 244 m is close to the actual Abo thickness.

However, Dutton's "upper Aubrey" thickness of 122 m is much thinner than the combined thicknesses of the Yeso (~320 m), Glorieta (~60 m) and San Andres (~45 m) formations, which is 425 m (Colpitts, 1989). Furthermore, Dutton's description of the "upper Aubrey" appears to refer only to the Glorieta and San Andres formations, not to the Yeso Formation lithotypes. He thus seems not to have distinguished the stratigraphic interval later recognized as Yeso Formation. Removing its lithotypes and thickness from the upper Paleozoic section in the Zuni Mountains renders Dutton's description of the "Aubrey Group" in the Zuni Mountains fairly accurate.

"Permian"

Dutton (1885, p. 134) noted that "the Permian series of the Plateau country has always been a troublesome one to the stratigrapher." He then went on to recount that in the area north of the Grand Canyon, characteristic Permian invertebrate fossils had been documented, and that he had found some of the same kinds of fossils near Fort Wingate in west-central New Mexico. Furthermore, Dutton accepted Walcott's (1880) idea that in the Grand Canyon region, the base of the "Shinarump Conglomerate" is the base of the Triassic.

Dutton identified the "Shinarump Conglomerate" in west-central New Mexico as the prominent, cuesta-forming conglomeratic sandstone interval that extends from just east of Fort Wingate along the northern flank of the Zuni Mountains, almost to Grants. This unit is actually the Sonsela Member of the Petrified Forest Formation, a sandstone/conglomerate unit in the middle part of the Upper Triassic Chinle Group section (see below). Thus, Dutton's 450 ft (137 m) of Permian strata in west-central New Mexico are the interval between the San Andres and the Sonsela, strata of Triassic age now assigned to the Moenkopi Formation and lower part of the Chinle Group (Lucas and Hayden, 1989; Lucas et al., 1997; Heckert, 1997). Dutton (1885, p. 134) described these rocks as follows:

> The Permian beds are distinguished for their dense and highly variegated colors—chocolate, maroon, dark brownish reds, alternating with pale, ashy gray

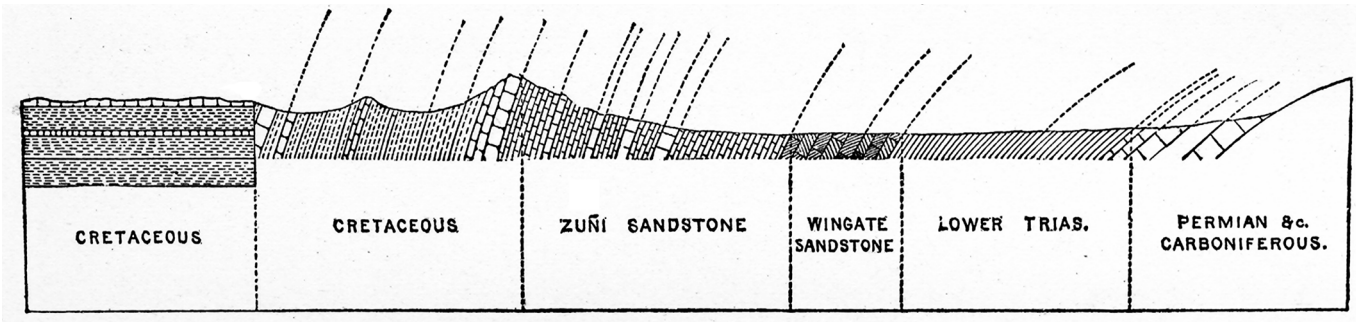

FIGURE 2. Dutton's (1885, fig. 5) cross section through the Nutria monocline.

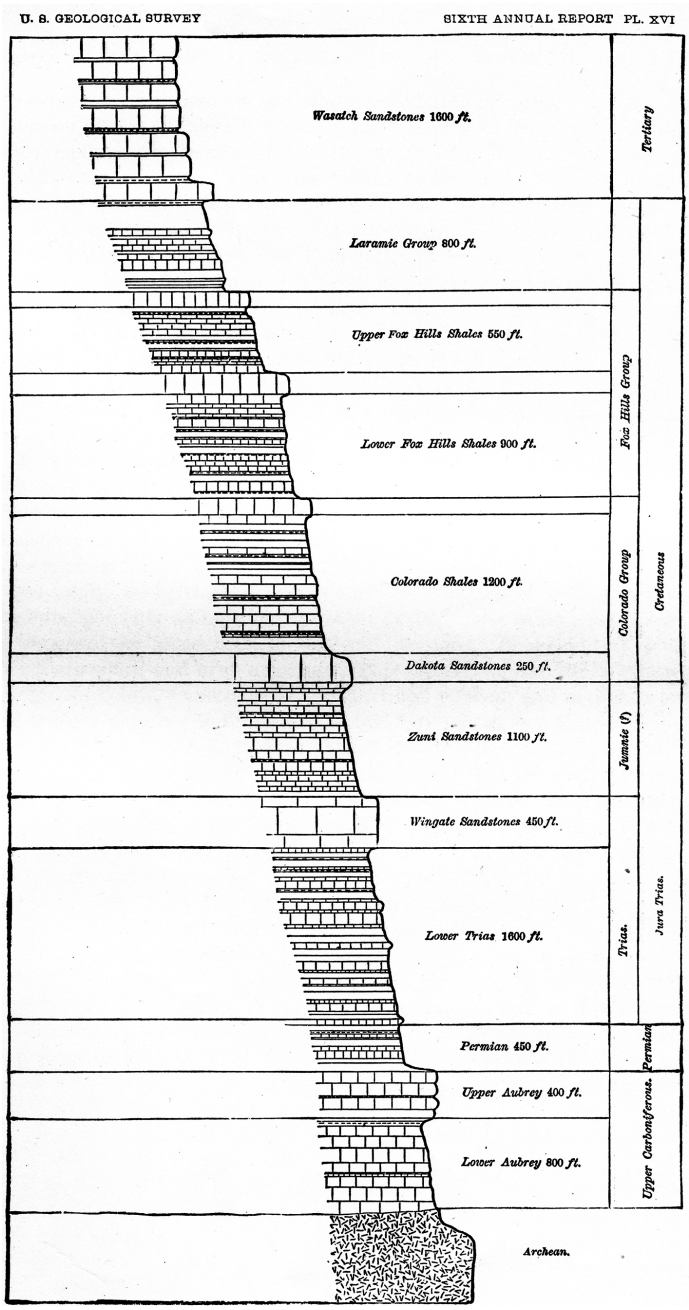

FIGURE 3. Dutton's (1885, pl. 16) summary of the stratigraphic section in west-central New Mexico.

> or lavender colors. They are sandy shales, containing gypsum and selenite in abundance, with here and there minor beds of limestone. It runs more to thin, sandy shales than anything else. In its upper portions it contains a great abundance of the silicified trunks of large coniferous trees.

This is a reasonable description of the lower part of the Triassic section in west-central New Mexico (Lucas and Hayden, 1989), and the actual thickness of this interval (~150 m) is close to Dutton's estimated 137 m. The logs Dutton referred to must be those in the Sonsela, and he thus erred in ascribing them to the Permian strata and not to his "Shinarump Conglomerate," which he considered Triassic.

Mesozoic

"Triassic"

Dutton (1885, p. 135) began his discussion of the Triassic strata much as he had begun his discussion of the Permian rocks, expressing uncertainty about the age, limits and correlation of the strata in west-central New Mexico that he assigned to the Triassic (as "Lower Trias": Fig. 3). Indeed, he noted that the Triassic "shales resemble so exactly the Permian below that it is quite impossible to distinguish them lithologically." In retrospect, this is not surprising, given that the "shales" being compared are those of the upper and lower parts of the Upper Triassic Chinle Group.

Dutton identified the "coarse sandstone" he correlated to the Shinarump (Sonsela of present usage) as the base of the local Triassic, and stated (p. 135) that "above it lie about 650 feet of dark, strongly colored sandy shales abounding in selenite and silicified wood." He went on to say (p. 136) that "above these dark shales lies a series of lighter colored, pale, dull-red shales the thickness of which I had no opportunity to measure satisfactorily…as nearly as could be inferred their thickness is about 800 or 900 feet." He also stated (p. 136) that "two thin bands of hard limestone, only four feet and three feet, respectively, in thickness, were noted, and after spending many hours in searching them for fossils….no semblance of a fossil could be found."

Based on recent work, it is clear that the strata Dutton described are those of the upper part of the Chinle Group. The 650 ft of dark sandy shales and the 800 or 900 ft of overlying shales he referred to belong primarily to the Painted Desert Member of the Petrified Forest Formation and have a total thickness of about 335 m (Repenning et al., 1969; Stewart et al., 1972; Lucas, 1993; Lucas et

al., 1997, 1999). The limestones are thin beds (~1-2 m thick) of the Owl Rock Formation, and which is about 20 m thick locally. Strata of the Rock Point Formation of the Chinle Group locally overlie the Owl Rock Formation in west-central New Mexico and are as much as 50 m of interbedded sandstone, siltstone and mudstone, but were not distinguished by Dutton. The upper Chinle Group on the northern flank of the Zuni Mountains thus has a total thickness of ~400 m, somewhat less than Dutton's estimate of ~472 m.

Dutton also assigned the overlying, cliff-forming sandstone, as much as 450 ft (137 m) thick, to the Triassic, noting (p. 136) that it is "the most conspicuous stratigraphic member of the whole region." He named this unit the Wingate Sandstones and provided three woodcut illustrations (Dutton, 1885, figs. 1-2, 11) of it (Fig. 4). Furthermore, Dutton proposed a broad, regional correlation of his Wingate Sandstones:

> The most superb cañons of the neighbouring region, the Cañon de Chelly and the del Muerto, the lofty pinnacles and towers of the San Juan country, the finest walls in the great upper chasms of the Colorado, are the vertical edges of this red sandstone….This formation is without much doubt the equivalent of the Vermillion Cliff series in southern Utah (p. 136-137).

Powell (1876) had introduced the term Vermillion Cliff group for sandstone-dominated strata in the Uinta Mountains of Utah that were later shown to be Upper Triassic Chinle Group strata (Baker et al., 1936). The cliff-forming sandstones of the Canyon de Chelly are Permian DeChelly Sandstone, and the "lofty pinnacles and towers of the San Juan country" are made by a range of Triassic and Jurassic strata. Strata of the Lower Jurassic Glen Canyon Group form the canyon walls of the upper reaches of the Colorado River. Thus, Dutton correlated his Wingate Sandstones too broadly, equating it to bold, cliff-forming units in Arizona, Utah and Colorado of Permian, Triassic and Jurassic age.

Ironically, this was but the first of many miscorrelations of the Wingate Sandstone, a topic still not fully resolved today (see, for example, Robertson and O'Sullivan, 2001 and Lucas et al., 2001). Most of Dutton's type Wingate Sandstone is now assigned to the Middle Jurassic Entrada Sandstone, which on the north flank of the Zuni Mountains has a maximum thickness of ~ 180 m, not far from Dutton's figure of 137 m (Condon and Peterson, 1986; Lucas and Anderson, 1998). The term Wingate Sandstone continues to be applied, however, to the lower 12 to 44 m of the sandstone cliff that Dutton originally called Wingate (Harshbarger et al., 1957; Lucas and Anderson, 1998; Heckert and Lucas, 1998; Lucas et al., 2001).

Jurassic

Regarding the rocks in west-central New Mexico that he regarded as Jurassic, Dutton (1885, p. 137) wrote:

> Above the Wingate sandstones comes another series of sandstones and sandy shales with occasional masses of gypsum, the thickness of which is also variable, ranging from 800 to 1,300 feet….It is wonderfully banded and variegated in color.

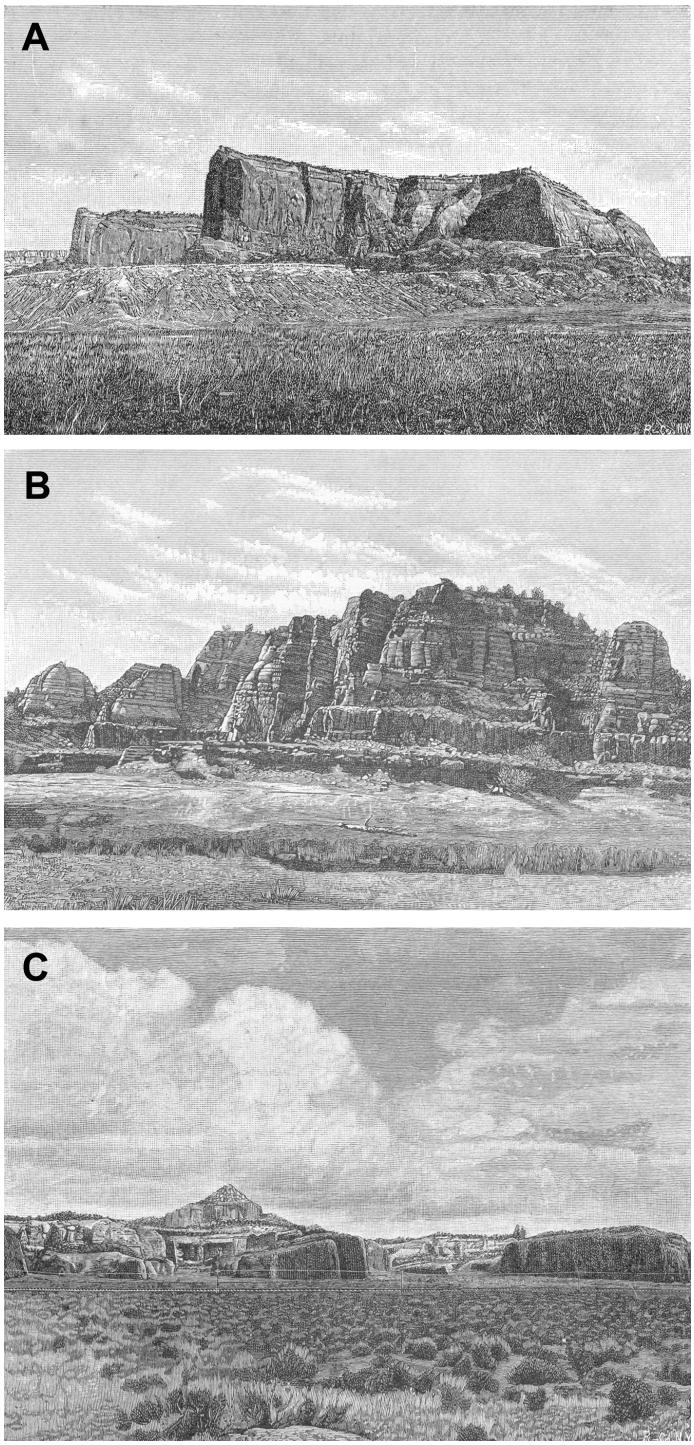

FIGURE 4. Dutton's (1885) three woodcut photographs of the Wingate Sandstone. A. His figure 1, described as "Wingate sandstone; the equivalent of the Vermillion Cliff sandstone of southern Utah." B. His figure 2, described as "Wingate sandstone, with many bands and partings; the same horizon as that shown in Fig. 1." C. His figure 11, described as "Pyramid Butte, near Fort Wingate, with promontories of the Wingate sandstone in front. The butte is composed of the Zuni sandstone." Pyramid Butte (Mountain or Rock) is in the SW ¼ sec. 2, T15N, R 17W, and the other images are of outcrops a few km to the east in T15N, R16W.

Dutton named these strata the "Zuni Sandstones" and tentatively assigned them a Jurassic age. He illustrated their outcrops near Zuni Pueblo in four woodcuts (Dutton, 1885, figs. 3, 10, 12-13) (Fig. 5).

Dutton offered no broad correlation of the Zuni Sandstones, as he had with the Wingate Sandstone. Indeed, he had problems correlating the unit within the confines of west-central New Mexico. Thus, the cliffs at Zuni Pueblo are composed of Zuni Sandstones according to Dutton, but those north of Fort Wingate are Wingate Sandstones overlain by the Zuni Sandstones. This correlation, of course, is incorrect, as the lower part of the cliffs around Zuni Pueblo are strata mostly correlative to Dutton's type Wingate Sandstones (Anderson, 1983).

Part of Dutton's confusion no doubt arose because he was misled by the color banding in the Zuni Sandstones near Zuni, much like the color banding of the Jurassic sandstones above his type Wingate Sandstone, which is a red cliff. Thus, Dutton correlated the Zuni Pueblo section in part correctly, equating it to the color banded sandstones above his type Wingate, but erred in not correlating the lower part of the type Zuni to the type Wingate.

North of Fort Wingate, Dutton's Zuni Sandstones included all the strata between the Entrada and Dakota sandstones. Thus, his Zuni Sandstones include strata now termed Todilto, Summerville, Bluff and Morrison formations of Middle and Late Jurassic age. The Acoma Tongue of the Zuni Sandstone, between the Bluff and Morrison Formation, also is part of this interval (Anderson, 1993; Anderson and Lucas, 1994).

At Zuni Pueblo, the Zuni Sandstone is ~152 m (500 ft) thick, and it is ~244 m (800 ft) thick at Church Rock (Anderson, 1983). So, Dutton's 396 m (1300 ft) maximum thickness estimate for the Zuni Sandstone is too much.

Cretaceous

Dutton (1885, p. 138) stated that "the Cretaceous system in the district examined is the same, in all essential respects, with the equivalent series which has been so well studied by Dr. Hayden's survey in Colorado." He thus assigned the Cretaceous section in west-central New Mexico to the (in ascending order) Dakota Sandstone (180 to 230 ft [55 to 70 m] of hard sandstone of "adamantine" texture), Colorado Shale (1200 ft [366 m] of "shaly beds"), Fox Hills shales (1450 ft [442 m] of coal-bearing strata) and Laramie Group (800 ft [244 m]). Dutton drew particular attention to the various persistent sandstone intervals that bracketed or split the Colorado, Fox Hills and Laramie groups (Fig. 3). He (p. 140) also noted that "the shaly and calcareous beds generally yield fossils," but offered few details on the lithotypes and no information on the Cretaceous fossils from west-central New Mexico. Instead, he reproduced Holmes' (1876) section of strata from the San Juan River valley (Dutton, 1885, pl. 17) and drew attention to the similarity of this section to the Cretaceous section in west-central New Mexico (Fig. 6). Dutton (1885, p. 140) also noted that the Cretaceous section "abounds in coal beds and bituminous matter….the quantity of this coal is enormous," and he devoted one woodcut (Fig. 7) to illustrating the Cretaceous strata.

Sears (1925), Sears et al. (1941) and Molenaar (1983, see especially fig. 4) well summarized the Cretaceous section in west-central New Mexico. Dutton's thickness estimate of as much as 250 ft (76 m) for the Dakota Sandstone is overstated, as the unit is less than 30 m thick (e.g., Sears, 1925). However, Dutton probably included part of the Morrison Formation with the Dakota, as had Holmes (1876), and this may account for the great thickness of the Dakota estimated by Dutton.

The Colorado Group (or shale or formation) of Hayden (1876) refers to the marine shale dominated section between the Dakota Sandstone and Fox Hills Formation. The unit Dutton called "Colorado Shales" in west-central New Mexico is thus the Mancos Shale between the Dakota and Gallup sandstones of current usage, and its thickness of 213-244 m is considerably less than the 366 m listed by Dutton.

The 125-ft (38 m) thick sandstone between the Colorado Shales and the "Lower Fox Hills Shales" in Dutton's scheme probably is the Gallup Sandstone (55-66 m thick: Sears, 1925). The 900 ft (274 m) thick overlying "Lower Fox Hills Shales" most likely included the Mulatto Tongue of the Mancos Shale and the lower part of the Crevasse Canyon Formation (Dilco Coal Member). The maximum thickness, though, of the Dilco plus Mulatto is about 200 m, considerably less than Dutton's'estimate.

Dutton's thick and subdivided Fox Hills shales indicate that he was using the term Fox Hills in the broad sense of White (1878, 1879). The original Fox Hills Beds of Meek and Hayden (1862) were a single, sandstone-dominated interval. But, White expanded usage of the Fox Hills to a group that included a significant interval of marine shale, the Pierre Shale of current usage. Furthermore, Holmes (1876) usage of Fox Hills (Fig. 6) was for a complex succesion of marine shales, shoreline sandstones and coal-bearing mudstones and sandstones in the San Juan Basin, the Point Lookout, Menefee, Cliff House, Lewis and Pictured Cliffs formations of current usage. Dutton thus included the same range of lithotypes in his "Fox Hills Shales."

The next, 175-ft (53 m) thick sandstone bed would be the Dalton Sandstone (about 55 m thick: Sears, 1925), which means the "upper Fox Hills Shales" of Dutton would be the Satan Tongue of the Mancos Shale and the Bartlett and Gibson Coal members of the Crevasse Canyon Formation. Dutton lists this interval as 550 ft (168 m) thick, but the Satan plus Bartlett plus Gibson maximum thickness is about 244-274 m (Sears, 1925).

The overlying 125-ft (38 m) thick sandstone in Dutton's scheme would be the Point Lookout Sandstone (thickness 30-61 m: Sears, 1925), overlain by the Menefee Formation, which Dutton termed the Laramie Group. Dutton lists the Laramie thickness at 800 ft (244 m), which is correct for the Menefee thickness at Gallup (Sears, 1925). Classically, the Laramie Formation (or Group) of King (1876) was a coal-bearing unit, but locally was recognized, for example, by Hayden (1876) in the Denver basin, to be sandstone and mudstone with little or no coal. The part of the Menefee Dutton examined, the "Allison Member," contains little or no coal (Sears, 1925; Sears et al., 1941).

In simply correlating the Cretaceous section in west-central New Mexico to the section along the San Juan River described by Holmes (1876), Dutton unknowingly advocated a major miscorrelation of much of the Cretaceous section. The mistake is in the correlation of the Fox Hills and Laramie strata. In west-central New Mexico, the strata Dutton called Fox Hills are Santonian-

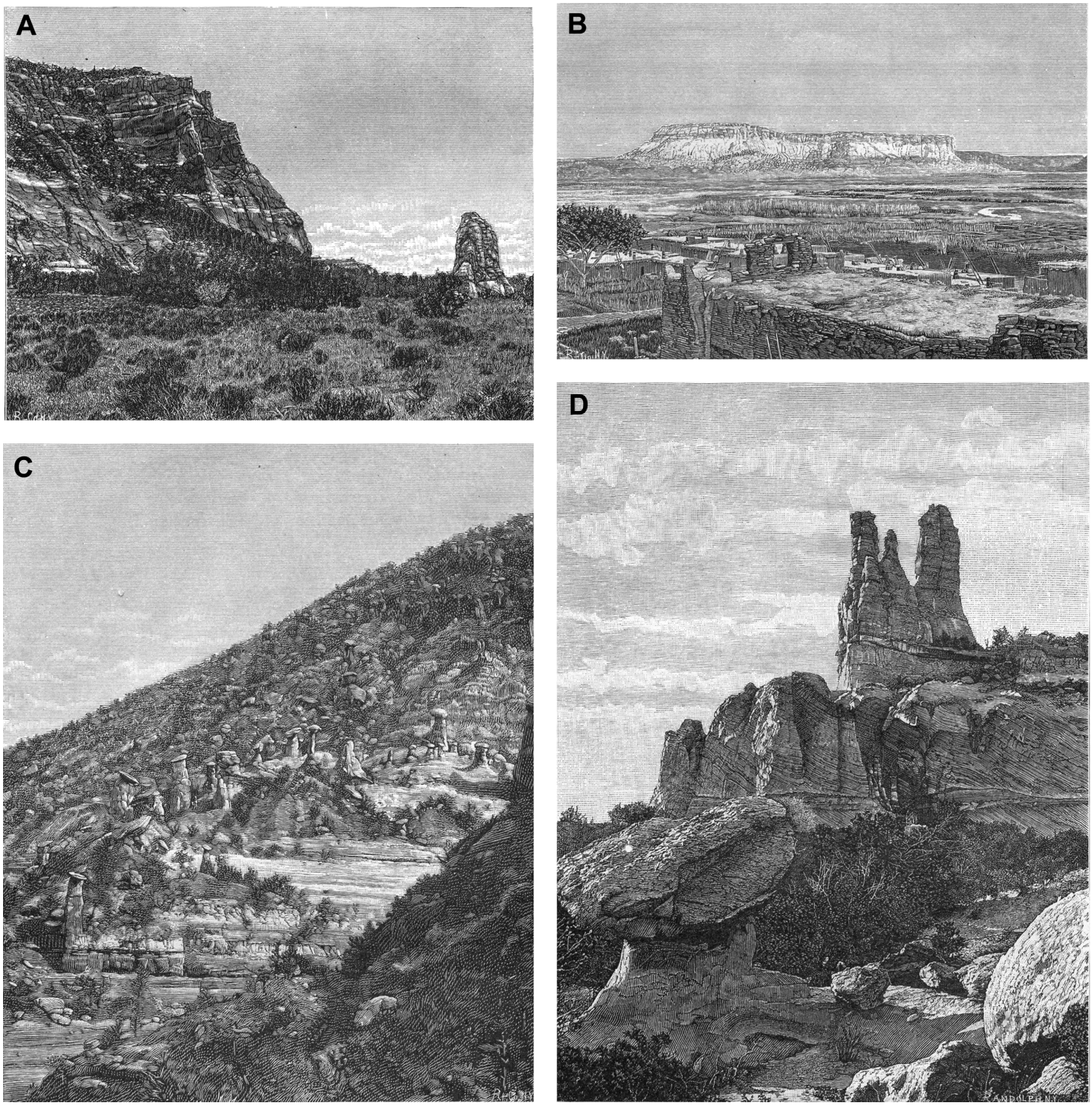

FIGURE 5. Dutton's (1885) four woodcut photographs of the Zuni Sandstone. A. His figure 3, described as "Zuni sandstones, consisting of the upper members of the Jura-Trias system." B. His figure 10, described as "Toyalané, a butte composed of the upper members of the Jura-Trias system, as seen from the housetops of Zuñi." C. His figure 13, described as "eroded towers, capped with large blocks of sandstone, which had fallen from the Dakota sandstone, nearly a thousand feet above. The protection which these afforded to the softer calcareous sandstone on which they lay caused the gradual formation of columns by the slow dissolution of the surrounding rock." D. His figure 12, described as "the Navajo Church near Fort Wingate. The rocks are the upper members of the Jura-Trias, and strongly cross-bedded." Dowa Yalanne ("Toyalané") is principally in sec. 36, T10N, R19W. The isolated rock in the upper left image is Feather Rock, in sec. 15, T10N, R18W and the image in the bottom left is just east or north of Feather Rock. The Navajo Church is in sec. 2, T15N, R17W, just northeast of Pyramid Rock.

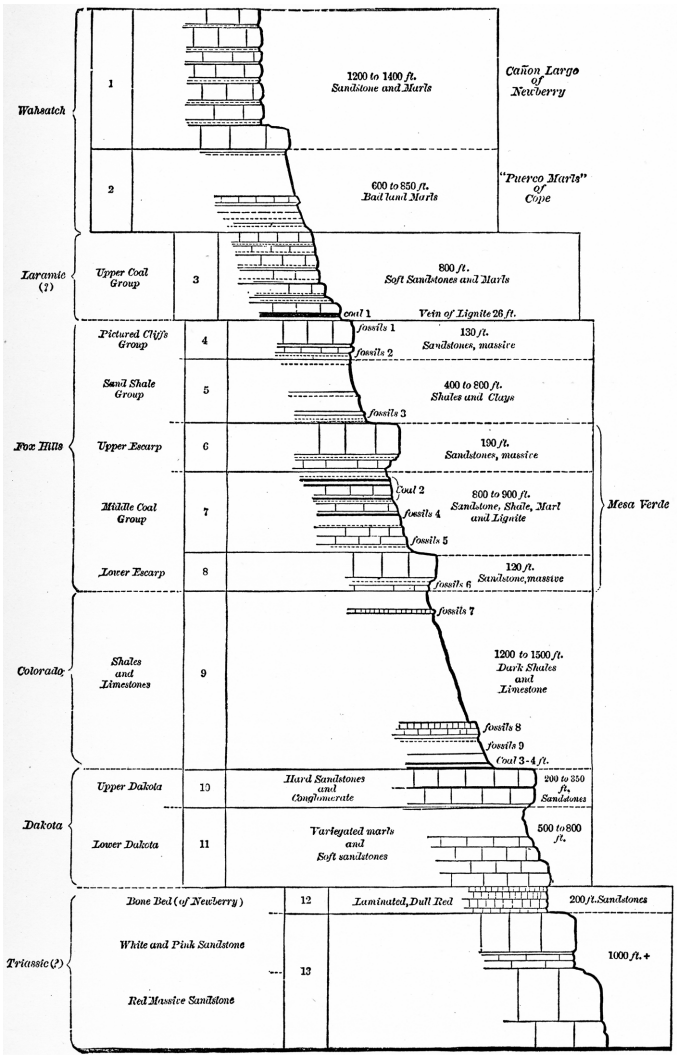

FIGURE 6. Dutton's (1885, pl. 17) reproduction of Holmes' (1876) stratigraphic section along the San Juan River in southwestern Colorado.

Coniacian age rocks of the Crevasse Canyon Formation and its marine equivalents. In contrast, Holmes' Fox Hills strata are younger; they are early Campanian strata of the Menefee Formation and its marine equivalents. Dutton's Laramie Group is early Campanian Menefee Formation and its marine equivalents, but Holmes' Laramie strata are the upper Campanian-Maastrichtian Fruitland and Kirtland formations. The primary basis for Dutton's miscorrelation is the presence of the Crevasse Canyon Formation in west-central New Mexico and its absence in the San Juan River section. Furthermore, Dutton had no fossil data with which to determine a biostratigraphic correlation of the Cretaceous section.

Paleogene

Eocene

The youngest stratigraphic interval Dutton recognized in west-central New Mexico is a thick succession of sandstones exposed

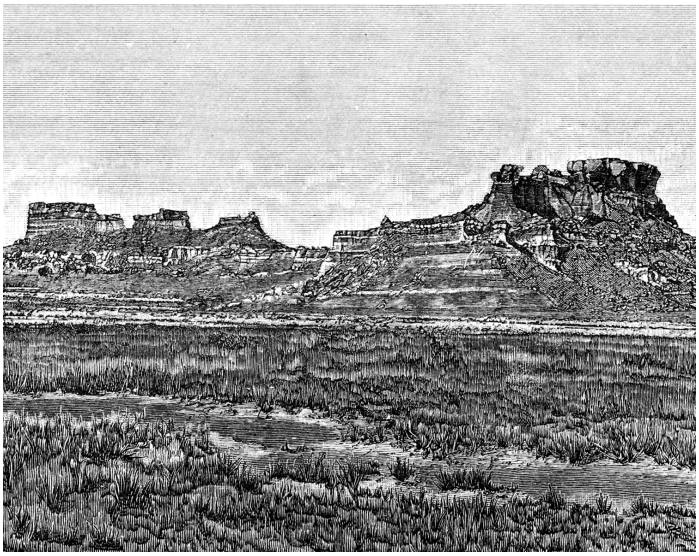

FIGURE 7. Dutton's (1885, fig. 4) woodcut photograph of Cretaceous strata, described as "buttes and mesa of the Middle Cretaceous." I am not certain of the exact location of this outcrop but believe it to be Crevasse Canyon or Menefee strata just north of Gallup in T15N, R18W.

in the high country of the Chuska Mountains. Dutton assigned this 1600-ft (488 m) thick sandstone interval to the "Wasatch Sandstones" of Eocene age, correlating them to strata in the east-central San Juan Basin that Cope (1875) had described.

Gregory (1917) named these strata the Chuska Sandstone and, like Dutton, correlated them to the early Eocene "Wasatch" (now San Jose) Formation in the eastern San Juan Basin. The Chuska Sandstone is now considered to be of late Eocene-early Oligocene age, and it has a maximum thickness of 580 m, somewhat more than Dutton's estimate (Wright, 1956; Lucas and Cather, this guidebook).

DISCUSSION

The preceding text largely evaluates the accuracy of Dutton's stratigraphy in terms of current stratigraphic understanding. Dutton's stratigraphy was conservative. He emphasized regional correlation of the Phanerozoic section in west-central New Mexico with other, already described sections on the Colorado Plateau, especially in the Grand Canyon and San Juan River regions. In so doing, Dutton introduced no new nomenclature for the Paleozoic, Cretaceous and Paleogene strata in west-central New Mexico, instead referring them to and stressing their similarities to units named elsewhere. This in part led Dutton to miss units not then known or present elsewhere (such as the Yeso Formation) and to grossly oversimplify and miscorrelate units (such as the post-Colorado Shale Cretaceous section).

Dutton's stratigraphic treatment of the Paleozoic and Cretaceous rocks in west-central New Mexico had little impact on subsequent stratigraphic analysis. Shaler (1907) and Gardner (1907) introduced the southwestern Colorado terms Mancos and Mesaverde for Cretaceous strata Dutton had termed Colorado and Fox Hills. And, the next worker to publish a stratigraphic

synthesis of the area, Darton (1910), applied a totally different nomenclature than had Dutton to the Paleozoic and Cretaceous rocks (Fig. 8). Gregory (1917) followed suit (Fig. 8).

Darton (1910) and subsequent workers retained Dutton's Wingate and Zuni sandstones. Unfortunately, erroneous correlations by Gregory (1917) and Baker et al. (1936, 1947) undermined and confused usage of the terms Wingate and Zuni as originally defined by Dutton. Only recently have these units been redefined and reidentified in west-central New Mexico so as to fit them into a lithostratigraphically sound regional stratigraphy of Triassic and Jurassic strata on the southern Colorado Plateau (Lucas and Heckert, this guidebook).

Nevertheless, we do well to remember that Dutton's (1885) report was the product of merely one summer of fieldwork. Moreover, the stratigraphy was only a part of the report; the more lengthy and more interesting (to Dutton) parts of the report focused on the Mt. Taylor volcanic field and the nature of monoclinal structures (Fig. 2). No doubt, had Dutton devoted more time to the stratigraphy he would have produced a more detailed, accurate and influential result. His inability to do so essentially nullified his contrtibution to understanding the regional Paleozoic and Cretaceous stratigraphy. However, his recognition of the Wingate and Zuni sandstones was of two valid and widespread lithostratigraphic units whose usage continues to this day.

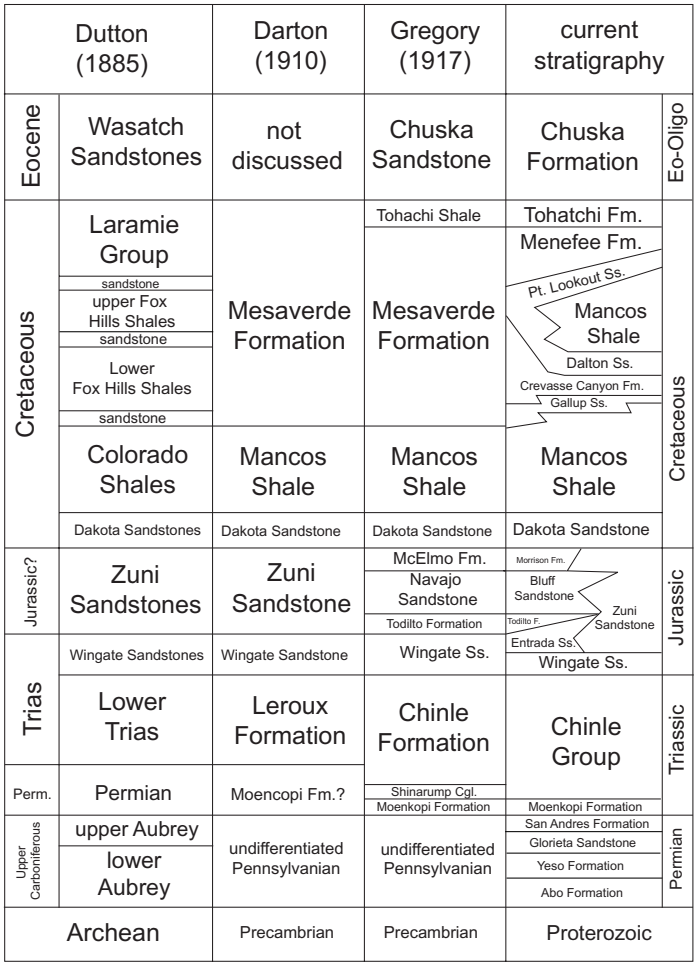

FIGURE 8. Dutton's stratigraphy compared with those of Darton (1910), Gregory (1917) and the currently used stratigraphy.

ACKNOWLEDGMENTS

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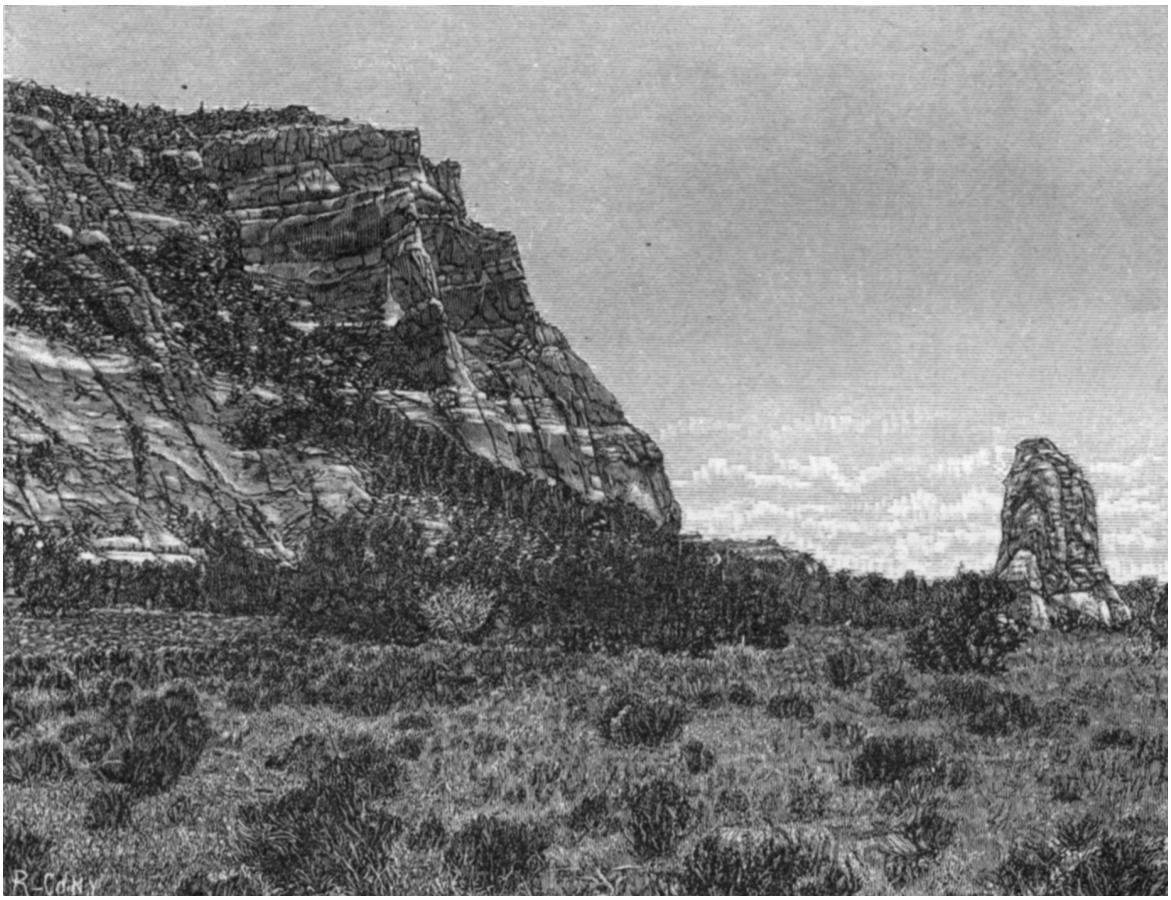

Dutton's (1885, fig. 3) woodcut photograph of the Zuni Sandstone, described as "Zuni sandstones, consisting of the upper members of the Jura-Trias system."