



## ***Historical background of the type locality of the Tres Hermanos Sandstone member of the Mancos Shale***

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## HISTORICAL BACKGROUND OF THE TYPE LOCALITY OF THE TRES HERMANOS SANDSTONE MEMBER OF THE MANCOS SHALE

By Carle H. Dane<sup>1</sup>

### INTRODUCTION

The derivation and definition of the name Tres Hermanos sandstone member of the Mancos shale of Late Cretaceous age has been the subject of confusion in the literature for many years. The Lexicon of Geologic Names (Wilmarth, 1938, p. 2181) reports that the derivation of the name is not stated in its original definition. Hunt (1936, p. 41), describing the area east of Mount Taylor, refers to "the three prominent sandstones in the lower 350 feet of the Mancos shale to which the name 'Tres Hermanos sandstone' has been applied in previous reports. Apparently this name was first used by Herrick and Johnson (1900a), though without recording a type locality." Givens (1957, p. 8), writing of the area that includes the type locality, says "the origin of the name Tres Hermanos is obscure." Similar references occur elsewhere, and a brief review of the literature also shows that several sandstones have locally been included together under the name, and suggests that elsewhere thinner, lower sandstones in the Mancos shale have been mistakenly identified with the Tres Hermanos sandstone member. Nevertheless, a reading of the most succinct and probably the first account of the Tres Hermanos sandstone (Herrick, 1900) and other pertinent references shows that there is no reason for doubt as to the type locality and little reason for misidentification of the specific sandstone defined.

### Herrick's reconnaissance from Albuquerque in 1899

Herrick's party left Albuquerque December 7, 1899, traveled west to the valley of the Rio Puerco, thence southward to what was then called the Alamosa Creek valley (now Rio Salado), traveled westward up that valley from the area north of the Bear Mountains, and returned to Albuquerque about 10 days after the start of their trip. (See fig. 1.) A quotation concerning the trip up the Alamosa Creek valley follows (Herrick, 1900, p. 341):

"West of the long tongue of lava-topped mesa that terminates in the three basaltic peaks of Tres Hermanos is a valley excavated in the Cretaceous . . . Passing up Alamosa River, which is chiefly excavated in the Cretaceous, the dip again becomes easterly (The dip becomes easterly as the beds rise on the east flank of the Red Lake anticline (Winchester, 1920, pl. V, and Givens, 1957, pl. I.) C.H.D.) and the strata rise about with the inclination of the valley. At range 8, north of the Alamosa, is a curious mountain formed by the protrusion of a basaltic neck through the soft strata. This Turtle Mountain forms the southern projection of a long terraced ridge at the foot of which is a good exposure of the maroon sands and marls of the vermilion division of the red series. Above this in successive benches the sands and shales of the Cretaceous are finely displayed **and follow the same sequence as in the Rio Puerco region** (Emphasis is mine. C.H.D.) . . ."

The party had passed through the Rio Puerco region east of Mount Taylor only a few days previously.

It is clear from the foregoing and from the "approximate geological map" accompanying the report that Herrick applied the name Tres Hermanos to the three dark

little igneous plugs in the north part of sec. 26, T. 3N., R. 7W. (Givens, 1957, pl. 1) still known by that name, and that he described the mountain now known as D-Cross Mountain as "Turtle Mountain." It is also clear that the sandstone to which the name Tres Hermanos was applied by Herrick also cropped out east of his Tres Hermanos Buttes and was "a band of sandstone with enormous concretions," for, to quote an earlier passage (Herrick, 1900, p. 341):

"East of Tres Hermanos is an exceptionally good exposure showing the three members of the red series and a considerable amount of the Cretaceous above. **The same sequence is observed at this place as near Albuquerque** (Emphasis is mine. C.H.D.). The Dakota sandstone appears to be absent and the so-called gasteropod (sic) zone is within a hundred feet of the bottom, with fossils of Fort Benton age, followed by a band of sandstone with enormous concretions. After a series of soft shales the zone of cephalopods appears and then the Fox Hills sandstones with their large marine assemblage."

The sequence near Albuquerque referred to is that exposed in the valley of the Rio Puerco west of Mesa Prieta and at some point north of San Ignacio, in which area Herrick (1900, p. 338) reported:

" . . . the whole series of Cretaceous as found in this area is exposed with a dip to the east and south-east. The sequence is as follows, beginning at the bottom:

	Feet
White and yellow sandstone	75
Dark and yellow shales	100
Fossiliferous zone with bands of sandstone and flags (gasteropod (sic) zone)	25
Yellow shales	100
Massive sandstone with large concretions (Tres Hermanos sandstone)	75
Shales with occasional flags (at least)	100
Zone of concretions with sandy flags (cephalopod zone)	25
Shales	80 to 100
Fossiliferous sandstone (Punta de la Mesa sandstone)	25 to 50

(The section above this level is not reproduced here. C.H.D.)"

Note that the sandstone here specifically identified as the Tres Hermanos sandstone is massive sandstone with large concretions lying between the gasteropod (sic) and cephalopod zones, which Herrick regarded as the same sequence as that exposed in the Alamosa Creek valley east of Tres Hermanos. The application of the name was to the sandstone as exposed in the Puerco Valley, but Herrick clearly, and it now seems correctly, believed that the same sandstone was exposed both east and west of Tres Hermanos, which name he chose to apply to the unit.

### The Tres Hermanos sandstone member, its extent and age

Hunt (1936, p. 43), writing many years later of the Puerco Valley east of Mount Taylor stated that the middle

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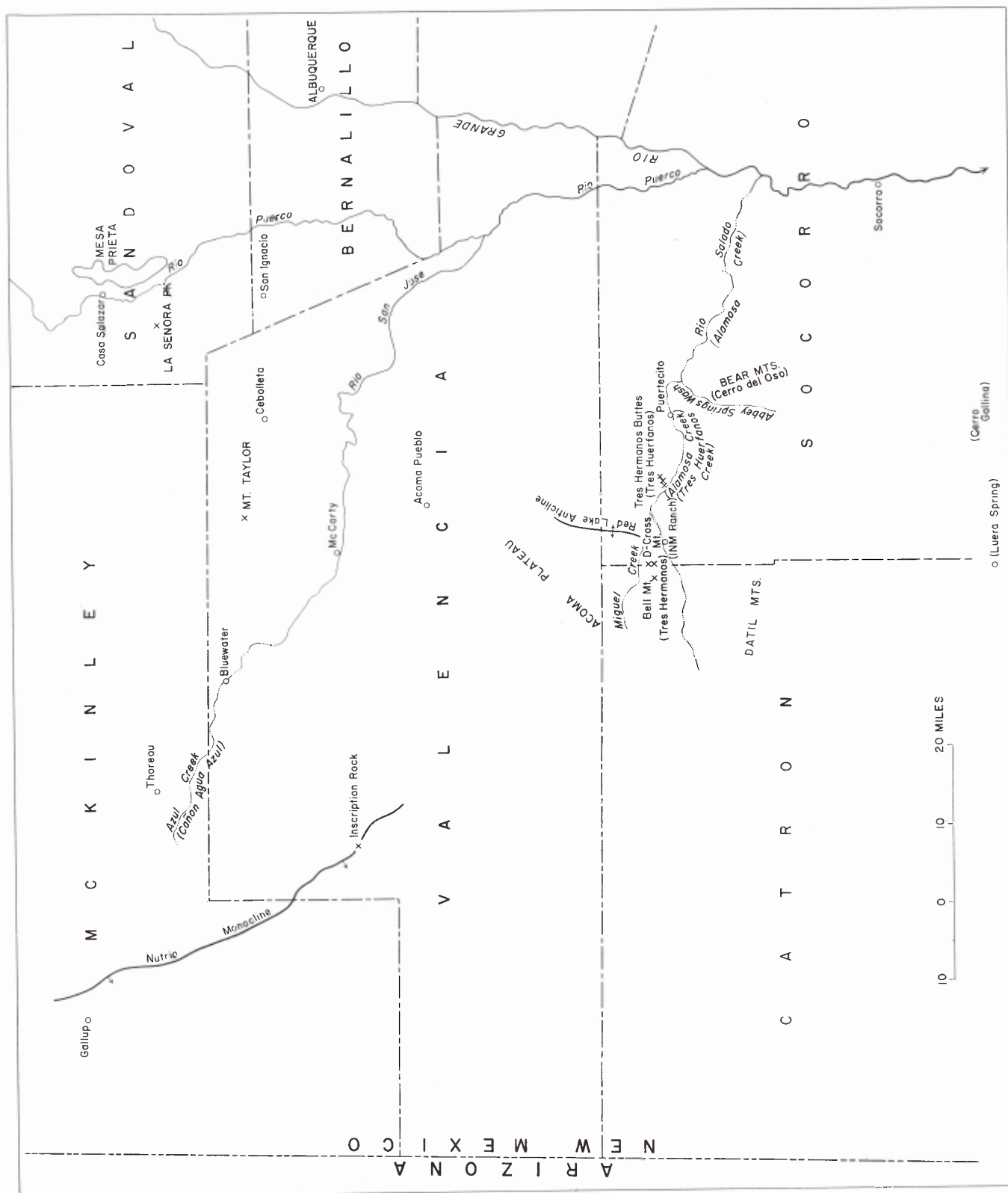


Figure 1. Index map showing location of some geographic and geologic features in the region around the type locality of the Tres Hermanos sandstone member. Former names of some features enclosed in parentheses.

of the three prominent sandstones that he mentions as occurring in the lower 350 feet of the Mancos shale (his sandstone No. 2) is the most persistent of the three. He noted that this middle sandstone is usually thick and massive, that it crops out as a prominent capping of mesas or

ridges east of Mount Taylor, and that it has abundant fossils scattered through large ferruginous concretions, many of which are as much as 10 feet in diameter and so hard and resistant to erosion that they commonly form conspicuous loose boulders. This description compares rather



strikingly with that of Herrick and Johnson (1900a, p. 14):

"In the lower layers of sandstone or in the upper sandy part of the shale below it there are frequently developed large concretions often with a cement of iron. These concretions may be over four feet in diameter and often become conspicuous objects in the landscape. They have been found at so many places in the same place in the series that we have come to attach considerable importance to them as a means of identifying horizons . . . Several species has (sic) been recovered from the concretions although they are not usually fossiliferous."

Hunt (1936, fig. 1) shows the base of this sandstone as about 200 feet above the top of the Dakota sandstone. The same sandstone extends for many miles south of Mount Taylor as a prominent persistent mesa-capping sandstone 200 feet or more above the Dakota, and Pike (1947, p. 75), in his section at D-Cross Mountain, measured 25 feet of the Tres Hermanos sandstone lying on 155 feet of shale above the Dakota.

A similar thickness of sandstone with large concretions at the base, lying about 200 feet above the Dakota sandstone in the western part of sec. 33, T. 2N., R. 5 W., on the east side of Abbey Springs Wash in the Puertecito quadrangle, must also be Tres Hermanos sandstone member, although Tonking (1957, p. 19) believed that the Tres Hermanos pinched out to the south in secs. 4 and 8, T. 2N., R. 5W. The Tres Hermanos is present on the south side of Mount Taylor in T. 10N., Rs. 8 and 9W., but its presence farther west has not been unequivocally established although several sandstone beds have been reported in the lower part of the Mancos shale (Young, 1956). In his report on the Thoreau quadrangle, Smith (1954) described the lower 200 to 300 feet of the Mancos as shale with a few local thin-bedded sandy lenses, abundantly fossiliferous in many localities, the fossils including *Gryphaea newberryi* and *Exogyra columbella*. Still farther west in the vicinity of Gallup, a persistent sandstone as much as 50 feet thick and containing *Gryphaea newberryi* in great numbers crops out 80 to 125 feet above the Dakota sandstone (Dane and Bachman, 1957, p. 96, 97) and may well be the Tres Hermanos sandstone as suggested by Pike (1947, p. 32).

Although Lee (1917, p. 174) used the name Tres Hermanos for the zone of sandstones 150 feet thick, presumably including Hunt's three prominent sandstones and the intervening shales, it would now seem best to restrict the use of the name to the single sandstone to which Herrick originally applied it (Hunt's sandstone No. 2 in the Puerco Valley) and to those sandstone beds that can be correlated with it.

The Tres Hermanos sandstone member as thus defined is of the age of some part, but not the uppermost part, of the Greenhorn limestone of Kansas, as *Gryphaea newberryi* has repeatedly been reported in it. The uppermost faunal zone of the Greenhorn, characterized by *Inoceramus labiatus* (Cobban and Reeside, 1952) which occurs in the limestone and marl beds of the Greenhorn limestone of the northern part of the San Juan Basin, is in the beds 50 to 150 feet above the Tres Hermanos. *Inoceramus labiatus* was collected at this level by the writer in the Puertecito area, and had previously been reported from shales at nearly the same level (above Hunt's No. 2 sandstone) at the foot of La Senora Peak (Shimer and Blodgett, 1908, p. 55), and also from 161 feet above the top of the Tres Hermanos (top of Lee's "upper plate of the Tres Hermanos

sandstone," containing *Gryphaea newberryi*) near Casa Salazar (Lee, 1917, p. 194-195). It is unfortunate, however, that most of the extensive collections made from the Puerco Valley (Lee, 1912) are neither stratigraphically nor geographically located with sufficient precision to be interpretable in terms of the stratigraphic units and faunal zones now recognized. That the beds just above the probable Tres Hermanos sandstone member near Gallup are not of uppermost Greenhorn age is also shown by the occurrence of a zone of bentonite beds about 40 feet above the top of the sandstone, which seems to correlate with a similar zone at the base of the Greenhorn limestone member of the Mancos shale in the northern part of the San Juan basin.

#### Winchester's study of the Alamosa Creek area, 1913-1914

A party under Dean E. Winchester made a detailed study of the coal resources of a part of northern Socorro County, New Mexico, in 1913 and 1914. Some years later, interest in the oil and gas possibilities made it desirable to record the observations made and the results were published as a report on the geology of the Alamosa Creek valley (Winchester, 1920). (The name Alamosa Creek has been since changed to Rio Salado.) Above the Dakota sandstone the lower part of the Cretaceous rocks was included in the Miguel formation (now abandoned) by Winchester, who wrote, "The Miguel formation includes four thick resistant and persistent beds of sandstone. The two lower may represent the Tres Hermanos sandstone of Lee (1916) but they are the least conspicuous of the sandstones of this area and were therefore not mapped. They are exposed a mile east of the Tres Hermanos Buttes."

The delay in preparation and publication of the Winchester report was probably responsible for some inconsistencies, such as the reporting of Tres Hermanos sandstone as Dakota in the area south of Puertecito. This has been mentioned previously (Dane, Wanek, and Reeside, 1957, p. 190) but is here more adequately shown on Figure 2 by the comparison and correlation of Winchester's section at D-Cross Mountain ("2 miles west of the I.N.M. ranch" (Winchester, 1920, p. 7)). the lower part of Pike's section at the same place, and Winchester's section south of Puertecito (Winchester, 1920, p. 7, 8).

The stratigraphic classification shown on figure 2 is that of Pike (1947, p. 74, 75), as modified by Dane, Wanek, and Reeside (1957, fig. 2). Tonking (1957) included the units from the top of the Tres Hermanos sandstone to the top of the Gallego sandstone member of the Gallup sandstone in his La Cruz Peak formation. Givens (1957), in the adjacent Dog Springs quadrangle, included the 162 to 196 feet of shale that overlies the Tres Hermanos in the upper shale member of the Mancos shale, but retained the name La Cruz Peak formation for the overlying beds up to and including the Gallego sandstone member.

The fossils listed on figure 2 adjacent to Winchester's section south of Puertecito were noted by the late J. B. Reeside, Jr. (written communication) in a re-examination of Winchester's fossil collections of 1913, which when transmitted were accompanied by a graphic section that is the one published (Winchester, 1920, p. 7, 8) as the section south of Puertecito. The basal sandstone of this section is correlated with the Tres Hermanos sandstone member of the D-Cross Mountain section on the basis of the occurrence in it of *Gryphaea newberryi* as well as by the self-evident correlation of beds. Unfortunately, Tonking (1957, fig. 6) accepted Winchester's published section as beginning at the base with the Dakota sandstone, thus rendering the correlation of his own section, reported as



4 miles southwest of Puertecito, also uncertain.

Of Winchester's two lower sandstones of the Miguel formation of former usage which he thought might represent the Tres Hermanos sandstone of Lee, only the lower one (25, 23, and 31 feet thick on fig. 2) is properly Tres Hermanos sandstone member and this unit lies 150 to 200 feet above the thin Dakota sandstone of this region.

#### G. K. Gilbert's reconnaissance of 1873 and usage of Tres Hermanos Buttes

In view of the interest in the identification of the type locality of the Tres Hermanos sandstone member, it is somewhat surprising that an earlier substitution of names for the Tres Hermanos Buttes has apparently not been noticed. The earlier name is recorded in the report made by G. K. Gilbert, then a 30-year old geologist associated with the geographical and geological explorations and surveys in charge of Lieut. G. M. Wheeler. In an expedition in 1873, 26 years prior to Herrick's journey up Alamosa Creek, Gilbert crossed northward between the Datil and Gallinas Mountains en route to Acoma and thus the discerning eye of one of the foremost geologists of an earlier day viewed the landscape and geological section of this area. It is quite evident from the text of his report (Gilbert, 1875, and also atlas sheet 77 of the Wheeler surveys) that Gilbert referred to the three basaltic masses now called Bell Mountain (sec. 14, T. 3N., R. 9W.) and the north and south parts of D-Cross Mountain (sec. 18, T. 3N., R. 8W.) as the Tres Hermanos Buttes. The present-day Tres Hermanos Buttes were then called Tres Huerfanos, and Alamosa Creek (now properly Rio Salado) was called Tres Huerfanos Creek. The occasion on which the name changes occurred in or prior to Herrick's trip in 1899 has not come to my attention, but of course the earlier usage is of historical interest only and should now have no effect on the present nomenclature.

Gilbert joined the 1873 expedition at a point near Fort Wingate in the latter part of July. After geologic examinations in that vicinity and near Inscription Rock, the party journeyed into central and southeast Arizona, thence following a course up the Mimbres and then up the Gila to its source. "Continuing northward by way of Luera Spring, the Tres Hermanos, Acoma and Cebolleta, we reached Agua Azul not far from the point of starting, late in November" (Gilbert, 1875, p. 505). Gilbert's report, transmitted October 19, 1874, contains much of interest on the geology of this whole region, but only a few passages that have some direct bearing on the Tres Hermanos sandstone member and associated Cretaceous rocks will be commented on here.

#### Gilbert's section of 1873 at D-Cross Mountain

Five local stratigraphic sections in New Mexico are given in Gilbert's report. The section in the Alamosa Creek valley is reproduced here (Gilbert, 1875, p. 549-550):

##### Section A

From the crest of the Datil range to the valley east of the Tres Hermanos buttes. Beds 1 to 2 and 8 to 14 were measured by aneroid barometer, the remainder estimated.

	Feet
1. Trachyte	800
2. Red clays, alternating with pale, incoherent sandstone	1,000

3. Shale, sandstone, and lignite; a series of rapidly alternating sandstone and shale beds, the sandstone of green-yellow color and soft, and the shale yellow and gray, with fillets of lignite	750
4. Massive yellow sandstone	75
5. Shaly yellow sandstone and gray shale	400
6. Massive yellow sandstone	75
7. Shaly yellow sandstone and gray shale	300
8. Massive yellow sandstone (Inoceramus)	75
9. Gray shale with band of limestone (Ostrea)	125
10. Soft orange sandstone	20
11. Gray, green, and blue argillaceous shale	100
12. Conglomerate of metamorphic pebbles	10
13. Red clay	200
14. Purple-brown sandstone, sectile and laminated	5
15. Purple clay, base not seen	50
Total	3,985

This compares with partial sections measured by Winchester (1920, p. 7, 2 miles west of I.N.M. ranch, p. 8, 9, north of Blue Mesa) and also includes upper beds like those measured at the north end of the Bear Mountains (1920, p. 10). It also includes the beds measured by Pike (1947, p. 74 and 75). The correspondence with these later, more detailed sections is good, although the thickness of the shale units 9 and 11 were underestimated. Beginning with the lower part of the section, beds 15, 14, and 13 are the Triassic, bed 12 the Dakota (cf. 15 ft. in Pike's section), bed 11 the lower part of the Mancos shale (cf. 155 ft. in Pike's section), bed 10 the Tres Hermanos sandstone member (cf. 25 ft. in Pike's section), bed 9 the upper part of the Mancos shale (cf. 206 ft. in Pike's section, and containing *Gryphaea newberryi* 20 feet above the base), bed 8 the lower bed of the Gallup sandstone (cf. 105 ft. in Pike's section, and with molluscan shells 30 feet above the base), bed 7 rocks of the Mesaverde group overlying the lower part of the Gallup and including the D-Cross tongue of the Mancos shale (Dane, Wanek, and Reeside, 1957, fig. 2) in the upper part (cf. 327 ft. in Pike's section), and bed 6 the Gallego sandstone member of the Gallup sandstone (cf. 98 ft. in Pike's section). Bed 3 represents the present Crevasse Canyon formation (Givens, 1957, p. 10), bed 2 the Baca formation and probably some of the upper part of the Mesaverde group, and bed 1 the present Datil formation. The section above and below beds 4 and 5 thus fits more detailed sections so remarkably well that one is strongly impelled to conclude that the D-Cross fault (Givens, 1957, pl. 1) was overlooked by Gilbert, as it was 40 years later by Winchester, and that bed 4 of Gilbert's section is the upfaulted repetition of the Gallego sandstone member that was formerly called Bell Mountain sandstone member of the Miguel formation.

A second passage from Gilbert's report (1875, p. 556, 557), pertinent in the foregoing connection because of its reference to his figure 161 (see fig. 3) but also of



interest in demonstrating the identity of one of his Tres Hermanos Buttes with D-Cross Mountain, follows:

"The Tres Hermanos buttes stand south of the Acoma plateau and north of the Datil range. Between them and the latter there runs eastward a water-course\* tributary to Tres Huerfanos Creek. The diagram, figure 161, represents the structure of the Cretaceous and Triassic strata, as shown on the left bank\*\* of the water-course. The proportions were not submitted to measurement but were estimated and sketched by the writer from the saddle. A birds-eye view was afterward obtained from the summit of the tallest butte, and the course of the disturbance traced. From the butte it runs ten miles northwest to the Acoma plateau, beneath which it disappears. In the opposite direction it could be traced but three miles, its course being directed toward the Sierra del Oso. To the west for ten miles at least, there is no similar disturbance; to the east, a mantle of basalt prevented observation. The throw of the fold—the difference of level, that is, between portions of the same stratum on opposite sides of the fold—is between 1,500 and 2,000 feet, and is to the southwest. The fold is older than the basalt of the vicinity. The eroded edges of the strata upturned by it support the lava caps of the Hermanos buttes and of the Acoma plateau. The level line of the Acoma lava shows that the folding has not continued since the eruption, and the antiquity of the eruption is measured by a general degradation of the country of more than 500 feet. The course of the fold, if produced, would carry it to the Nutria fold at Inscription Rock, and it accords with that in the direction of its throw; but these coincidences will not suffice to establish the identity of folds fifty miles apart . . . "

—a speculation that was appropriately qualified. Note that the lower level of the lava on the right (northeast) side of Gilbert's figure 161 represents the lava cap of present-day Tres Hermanos Mesa just north of Tres Hermanos Buttes (Givens, 1957, pl. 1).

#### Gilbert's section at Acoma

Gilbert's section near Acoma (1875, p. 553, 554) includes Jurassic rocks and overlying Cretaceous rocks up to the top of Tres Hermanos sandstone member. It is reproduced below:

#### Section E Near the pueblo of Acoma

	Feet
1. Massive, cross-bedded sandstone; yellow, stained superficially with red and brown	40
2. Gray and yellow, gypsiferous shale	260
3. Sandstone with fucoids	5
4. Gray and yellow shale with a foot of coal	15
5. Massive, friable, cross-bedded sandstone:	
a. Pink, weathering brown, soft	30 feet)
b. Yellow and firm; pebbly and banded ) with white near top	250 feet)
c. Soft; olive-green, with brown ) band 100 feet below the top	580 feet)
d. Soft; red	150 feet)
Total	900

\* The upper part of Rio Salado above its junction with Miguel Creek.

\*\* North bank.

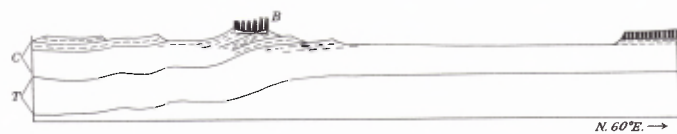


Fig. 161.—Section of monoclinical fold on Tres Huerfanos Creek, New Mexico. Scale,  $\frac{1}{72000}$ . C, Cretaceous; T, Trias; B, basalt of one of the Tres Hermanos buttes.



Fig. 159.—Cliff profiles near Acoma, N. Mex.

Figure 3. Geological sketches by G. K. Gilbert in 1873 showing Cretaceous and Triassic rocks near D-Cross Mountain (one of his Tres Hermanos Buttes) and near Acoma. Figure numbers and titles from Gilbert (1875).

The markedly crossbedded character of the Tres Hermanos (unit No. 1) near and south of Acoma is shown, and its conspicuous habit as the prominent mesa-capping ledge of this vicinity is shown in the accompanying reproduction (fig. 3) of Gilbert's figure 159, which identifies bed 1 of section E.

The lower Mancos shale (unit No. 2) is usually thick in this vicinity, as is recorded by Gilbert's section, and especially noteworthy is the thin "sandstone with fucoids" (unit No. 3) which represents the Dakota sandstone. This compares with the sandstone 10 feet thick above the carbonaceous shale unit along the road to McCartys about 4 miles northwest of Acoma. This basal Dakota sandstone here contains *Halymenites major* Lesquereaux, supposedly restricted in its occurrence to marine rocks, especially sandstones, of not older than Late Cretaceous age. According to W. A. Cobban (oral communication) this is the oldest occurrence of *Halymenites major* known to him, and it occurs beneath a collection of fossils including *Calyco-ceras* sp., a genus diagnostic of the oldest Late Cretaceous faunal zone. The 54 feet of carbonaceous shale underlying the *Halymenites*-bearing sandstone at this locality and the 15 feet of gray shale with coal (unit No. 4) of Gilbert's section thus possibly represent a Cretaceous unit of pre-Dakota age.

Although it is not pertinent to the general subject of this note, it is of interest that Gilbert described the lateral change in character of the pre-Cretaceous rocks near Acoma, as shown in his figure 159 and in the following words (1875, p. 548):

"At Acoma there is apparently a gradation in point of coherence in the upper sandstone within a single field of view. I say 'apparently' because I had not time to ascertain that there was or was not a change of texture and saw only a progressive change in the character of a long cliff, such a change as would naturally result from a change in the constitution of its material. In the diagram (figure 159) the profile at the left is that of the section which was measured (see section E sub.) and exhibits Cretaceous strata between the points 1 and 4 and Triassic below. The continuity of l, l, l, l and b, b,



b, b could be traced by their colors as well as by their forms. The right hand section presents the character of the slope at a distance of six or eight miles, and the others at intermediate points."

The observations of Gilbert in the area that he crossed more than 85 years ago, east of D-Cross Mountain, near Acoma, and elsewhere, are obviously now only of historical interest to geologists. They do demonstrate, however, that observations carefully made and accurately recorded can be readily interpreted and translated into the framework of later, more detailed geologic knowledge.

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