Evolution of stratigraphic nomenclature of the Upper Cretaceous of Socorro County, New Mexico

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Introduction

This paper is the companion piece to an article on the paleontology and stratigraphy of the marine Upper Cretaceous of Socorro County that was published in the 1983 New Mexico Geological Society Guidebook (Hook, 1983). Only general information on the stratigraphy and paleontology of Socorro County is presented in this paper; details can be found in Hook (1983) and in Hook and others (1983).

Molenaar (1983a) recognized that Upper Cretaceous rocks in Socorro County were deposited during the two earliest of the five major cycles of transgression and regression of the Late Cretaceous shoreline in New Mexico. These two cycles were referred to as the Greenhorn and Carlin units of the Cretaceous. Marine Upper Cretaceous rocks in Socorro County are approximately 1,000 ft thick and consist of the upper part of the Dakota Sandstone, an unnamed lower part of the Mancos Shale, the lower and upper members of the Tres Hermanos Formation, the D-Cross Tongue of the Mancos Shale, and the Gypsum Sandstone (Figs. 1a-b). Nonmarine rocks consist of the lower part of the Dakota Sandstone, the middle member of the Tres Hermanos Formation, and the Crevasse Canyon Formation. The Crevasse Canyon Formation is erosional truncated, but exceeds 1,000 ft in thickness in much of the county. In the northern part of the county, the Twowells Tongue of the Dakota Sandstone subdivides the lower part of the Mancos Shale into an unnamed lower tongue and the Rio Salado Tongue of the Mancos Shale (Figs. 1a-b).

The emphasis of this paper is the Upper Cretaceous exposed in the Carthage area and from Puertecito to D Cross Mountain. Terminology applied to the Upper Cretaceous exposed in the Jornada del Muerto coal field and in the Joyita Hills is similar to that of the Carthage area. The major references for these two areas are Darton (1928), Wilpolt and Wanek (1951), and Tabet (1979).

Previous Investigations

Cretaceous rocks in Socorro County have been mentioned in the published literature since at least 1868 when the entomologist John L. Le Conte (1868, p. 136) mentioned the "unmetamorphosed coal from the coal mine eight miles east of San Antonio and the Rio Grande" in his study of Cretaceous coals in New Mexico. Interest has continued during the intervening 116 years in part because of the economic importance of coal, but just as importantly because of the good exposures and abundant fossils.

Socorro County contains the type localities for the following Upper Cretaceous guide fossils: Coilocopoceras colleti Hyatt (1903), C. i-
FIGURE 1a—Stratigraphic cross section of Upper Cretaceous rocks from Carthage north to the Joyita Hills, Socorro County, New Mexico (Hook, 1983; provided by C. M. Molenaar).

FIGURE 1b—Stratigraphic cross section of Upper Cretaceous rocks from Carthage northwest to D Cross Mountain, Socorro County, New Mexico (Hook and others, 1983; Riley section from Massingill, 1979). See Fig. 1a for explanation of symbols.
Rankin's Greenhorn Limestone is exactly equivalent to the Bridge Creek Limestone Beds as presently used. Rankin also correlated the upper half of the present Tres Hermanos Formation with the Juanita Lopez Member of the Carliile Shale, a correlation that works well paleontologically, but not lithologically (Hook and others, 1983).

Pike (1947), in his classic study of intertonguing Upper Cretaceous rocks, extended the stratigraphic nomenclature of the Zuni Basin and the southern San Juan Basin to the Carthage area (Fig. 2). He was the first to use the name Gallup Sandstone at Carthage, referring to a unit that is split into lower and upper parts by the Pescado Tongue of the Mancos Shale. Although Pike's correlations with rock units in the Zuni Basin were essentially correct, he erred in including the Tres Hermanos Formation as the lower part of the Gallup Sandstone. Molenaar (1974) used essentially the same stratigraphic framework as Pike, but he recognized the need to use the D-Cross Shale terminology and introduced the Crevasse Canyon Formation terminology for the coal-bearing sequence.

Between 1947 and 1974, a more simplified and/or informal terminology was employed by Wilpolt and Wanek (1951), Cobban and Reeside (1952), Budding (1963), and Dane and Bachman (1965). Wilpolt and Wanek (1951) recognized three major units, the Dakota(?), the Mancos, and the Mesaverde, but they subdivided the Mancos Shale into three informal members, a lower and upper shale member subdivided by a middle sandstone member. Budding (1963) used essentially the same terminology as Wilpolt and Wanek. Cobban and Reeside (1952) used the same three major subdivisions, but they recognized a limestone member in the lower part of the Mancos Shale that is equivalent to Rankin's (1944) Greenhorn Limestone. The limestone unit was later correlated with only part of the upper member of the Greenhorn Formation by Hook and Cobban (1981) and was designated the Bridge Creek Limestone Member of the Mancos Shale at Carthage. Subsequently, Hook and others (1983) reduced the Bridge Creek Limestone to a bedrock unit of the Mancos Shale. The state geologic map (Dane and Bachman, 1965) employs this same threefold division of the Cretaceous.

Cobban and Hook (1979, 1983), Hook and others (1983), and Molenaar (1983a, b) correlated the middle sandstone member at Carthage with the Tres Hermanos Sandstone of Herrick (1900). Cobban and Hook (1979) used the Tres Hermanos Sandstone as a member of the Mancos Shale following Lee's (1916) usage. Hook and others (1983) later raised the Tres Hermanos to formal rank.

Figure 2 shows the evolution of the stratigraphic nomenclature at Carthage in graphic form. Although the units are not drawn to stratigraphic scale, nomenclature equivalent to that used in this paper can be traced horizontally across the diagram.

**D Cross Mountain–Puertecito area**

Formal studies of Cretaceous rocks in northwest Socorro County date back to 1875 (Table 2) with the publication of Gilbert's measured section in the valley east of the former Tres Hermanos Buttes, a name then used to refer to the north and south parts of D Cross Mountain and Bell Mountain. The present-day Tres Hermanos Buttes were then called Tres Huerfanos, and Alamosa Creek (now the Rio Salado) was called Tres Hermanos Creek. The occasion on which the names changed is unknown (Dane, 1959). Herrick (1900) used the name Tres Hermanos Buttes in the same sense as today, but he referred to D Cross Mountain as Turtle Mountain.

The name, D Cross, refers to natural-rock groupings on the south-facing slope of the mountain that resemble the letters D and X.

Gilbert's section, which was partly measured with an aneroid barometer and partly estimated during the 1873 field season, is of more than just historical interest because it demonstrates that "... observations carefully made and accurately recorded can be readily interpreted and translated into the framework of later, more detailed geologic knowledge" (Dane, 1959, p. 91). Although Gilbert applied no formal stratigraphic names to his units, they can be correlated easily with the formally named units used today because he integrated both physical and paleontological data into his description (Table 2). Gilbert was the first geologist to recognize the stratigraphic importance of the Bridge Creek Limestone Beds and their contained fauna. These beds were designated as unit 9 by Gilbert and described as gray shale with a band of limestone containing Ostrea. The band of limestone is the base of the Bridge Creek Limestone Beds and the Ostrea is *Pycnodonte newberryi* (Stanton), which occurs in great numbers at D Cross Mountain (Hook and Cobban, 1977, fig. 3). Gilbert (1875) was also the first geologist to measure a section across the D Cross Mountain fault (Givens, 1957) which duplicated the upper part of the section (Table 2, units 4 and 5). This error was later committed by both Winchester (1920) and Pike (1947), leading to discrepancies in the thickness of the marine Cretaceous rocks that were not corrected until 1957 (Dane and others, 1957).

Clarence L. Herrick, one of the unsung pioneers of New Mexico geology, journeyed up Alamosa Creek in December, 1899, and studied the Upper Cretaceous of that area. His contributions to geology, particularly the naming of the Tres Hermanos Sandstone in the Puertecito area (Fig. 3), have been a matter of considerable confusion and controversy since 1900. This controversy is discussed.
TABLE 1—GARDNER’S (1910, PP. 454–455) MEASURED SECTION OF THE UPPER CRETACEOUS AT CARTHAGE. Updated information is in brackets.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Lithology</th>
<th>Thickness ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montana:</td>
<td>Sandstone, tan-colored and drab shale with traces of coal</td>
<td>600</td>
</tr>
<tr>
<td>Sandstone and thin beds of sandstone, top contains Ostrea sp.</td>
<td>[Flemingostrea sp.], Anomia micromera Meek?; Mollusca [Brachiopoda] related to M. [B.] regularis (White); Corbicula? sp., Curvula? sp., Melania? sp., and Adnetopsis sp.</td>
<td>40</td>
</tr>
<tr>
<td>Coal, Carthage</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Shale, drab [Crevasses Canyon Formation from this unit to top of section]</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Sandstone, massive, brown</td>
<td>[Gallup Sandstone]</td>
<td>20</td>
</tr>
<tr>
<td>[Total thickness]</td>
<td></td>
<td>[685]</td>
</tr>
<tr>
<td>Colorado:</td>
<td>Shale, drab, with yellowish lime concretions</td>
<td>120</td>
</tr>
<tr>
<td>Shale, yellowish, with brown sandstone [D-Cross Tongue of Mancos Shale, this unit and the one above]</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Sandstone, massive, soft, brown, fossiliferous containing Ostrea sp., Ostrea lugubris var. bellipicata Shumard [Lopha bellipicata novomexicana Kauffman], Pinna sp., Pholadomya sp., Fasciolari? sp., Prionotropis woolgari (Mantelli)? [Prionocyclus macombi Meek], and Collopoceras colleti Hyatt [Fite Ranch Sandstone Member of the Tres Hermanos Formation]</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Shale, drab [Carthage Member of the Tres Hermanos Formation]</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Shale, drab, with thin brown sandstone</td>
<td></td>
<td>135</td>
</tr>
<tr>
<td>Sandstone, massive, gray</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Sandstone and shale, in center fossiliferous sandstone containing Inoceramus labiatus (L. subhercynicus), Cardium sp., Cypridinia sp., Psolomya sp., Fasciolari? sp., and Volotuderma? sp. [Aratare Sandstone Member of the Tres Hermanos Formation, this unit and the two above]</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Shale, drab [lower part of the Mancos Shale]</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>[Total thickness]</td>
<td></td>
<td>[895]</td>
</tr>
<tr>
<td>Dakota(?):</td>
<td>Sandstone, hard, gray, in bold hogback, some thin shale</td>
<td>200</td>
</tr>
</tbody>
</table>

![New Mexico Geology May 1984](https://example.com/newmexico.png)
Mountain. Molenaar believed that there was too much confusion surrounding the Tres Hermanos Sandstone, so he included it in the Gallup Sandstone and called it the Atarque Member. Molenaar's (1974) Atarque and others (1983), Molenaar (1983a, b), and Osburn (1983).

The stratigraphic terminology presently in use in the D-Cross—Puertecito area (Fig. 3) resulted in part from a cooperative agreement between the New Mexico Bureau of Mines and Mineral Resources and the U.S. Geological Survey to determine the coal resources of the Acoma and Zuni Basins. That terminology, including the recently defined Rio Salado Tongue of the Mancos Shale and the newly revised Tres Hermanos Formation (Hook and others, 1983) will be used on all the maps that result from that agreement. In the northwest corner of Socorro County, Hook and others (1980, fig. 2) recognized an additional, lower marine tongue of the Dakota Sandstone, the Paguate Tongue. The Paguate, however, pinches out into the lower part of the Mancos Shale approximately 2 mi north of the measured section at D Cross Mountain (Fig. 1). North of this pinchout, the lower part of the Upper Cretaceous in Socorro County consists of, in ascending order, the Dakota Sandstone, the lower part of the Mancos Shale, the Paguate Tongue of the Dakota Sandstone, the Whitewater Arroyo Tongue of the Mancos Shale (not Clay Mesa Tongue as erroneously stated in Hook, 1983, p. 166), and the Twowells Tongue of the Dakota Sandstone.

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References


Gilbert, G. K., 1875, Report on the geology of portions of New Mexico and Arizona examined in 1873: Report upon geographical and geological explorations and surveys west of the one hundredth meridian (Whiteread), v. 3, pt. 5, pp. 503-567.


From 1900 to the present.


