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CRETACEOUS STRATIGRAPHY OF THE FOUR CORNERS AREA

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INTRODUCTION

This paper briefly describes Cretaceous sedimentary rocks exposed in the Four Corners area of Utah, Colorado, Arizona and New Mexico (fig. 1). Although they originally formed a thick blanket over the entire Colorado Plateau, Cenozoic erosion has stripped them from the large structural highs and spared them in the deeper structural depressions such as Black Mesa, San Juan and Blanding basins. These remnants retain impressive thicknesses—as much as 1500 feet in the San Juan basin—attesting to the immense volume of sediment deposited here in the Cretaceous.

GENERAL FEATURES

Cretaceous strata of the Four Corners area contain a reasonably complete record of sedimentation and tectonic events in this portion of the Colorado Plateau. During Cretaceous time the area lay within the rapidly subsiding Rocky Mountain geosyncline about 200 miles from its southwestern margin. Sediments which accumulated here consist of intertonguing marine and nonmarine deposits reflecting the shifting of depositional environments during four separate southwestward transgressions and subsequent regressions of the sea across much or all of the area.

Depositional Environments

Cretaceous deposits in the western interior were formed in a great variety of depositional environments which existed essentially as a series of belts subparallel to the shifting strandline. Continental environments included the piedmont, which formed a narrow belt adjacent to the Mesocordilleran highland far to the west; and the floodplain, which graded into the piedmont on the west and extended eastward for varying distances before giving way to transitional environments near the shoreline. As the sea intermittently advanced westward in Early Cretaceous and early Late Cretaceous time the floodplain environment gradually shrank from hundreds to perhaps a few miles in width but expanded eastward as the sea retreated in Late Cretaceous time. Subenvironments recognized include meandering channel, braided channel, interchannel and lacustrine.

Transitional environments generally formed much narrower belts and tended to maintain their widths as they shifted first landward and then seaward in response to fluctuations of the shoreline. Environments present include paludal, deltaic, lagoonal-estuarine and littoral marine. Subenvironments recognized in the paludal environment include meandering channel, braided channel, interchannel and coal swamp. Deltaic subenvironments included distributary channel, interdis tributary bay and swamp, delta front and prodelta slope. Lagoonal-Estuarine subenvironments were lagoon pond, salt marsh, tidal channel, tidal delta, tidal flat and estuarine. Littoral marine subenvironments included backshore beach and dune, foreshore beach, breaker bar, offshore beach, organic reef and shoal.

The marine realm was represented only by the neritic environment which, like the floodplain environment, fluctuated greatly in width as the seas transgressed and regressed. Nearshore and offshore subenvironments can be recognized in the resulting deposits.

Stratigraphic Subdivisions

Cretaceous rocks discussed in this report include only those present in the Black Mesa basin, along the western side of the San Juan basin and at the southern edge of the Blanding basin. Some stratigraphic names are common to all three areas but others, particularly those of the upper portion of the sequence, can be applied in only one area. The general succession is, in ascending order, Burro Canyon Formation, Dakota Sandstone, Mancos Shale, Mesaverde Group, Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale and Ojo Alamo Sandstone (in part). Many of these major units have been further subdivided into lesser units, some referred to as units and others as formations, members or tongues, as shown in Figure 2.

Dakota Group

In this area the nonmarine and transitional deposits formed prior to, and during the southwestward transgression of the Cretaceous sea include the Burro Canyon Formation and the overlying Dakota Sandstone. Together they comprise the Dakota Group.

Burro Canyon Formation

As defined by Stokes and Phoenix (1948), the Burro Canyon Formation at its type locality near Slick Rock, Colo., consists of alternating conglomerate, sandstone, shale, limestone and chert ranging in thickness from 150 to 260 feet. It, or its genetic equivalent the Cedar Mountain Formation, is present over most of the northern two-thirds of the Colorado Plateau (Young, 1960). The Burro Canyon consists of deposits of the floodplain environment which occupied a broad belt east of the rising Mesocordilleran geanticline prior to and during encroachment of the Mancos sea. At several horizons in the formation are persistent, widely traceable, conglomeratic sandstones interpreted as deposits of a braided channel subenvironment. Sandwiched between these sandstones are variegated mudstone units with some sandstone and siltstone lenses—the

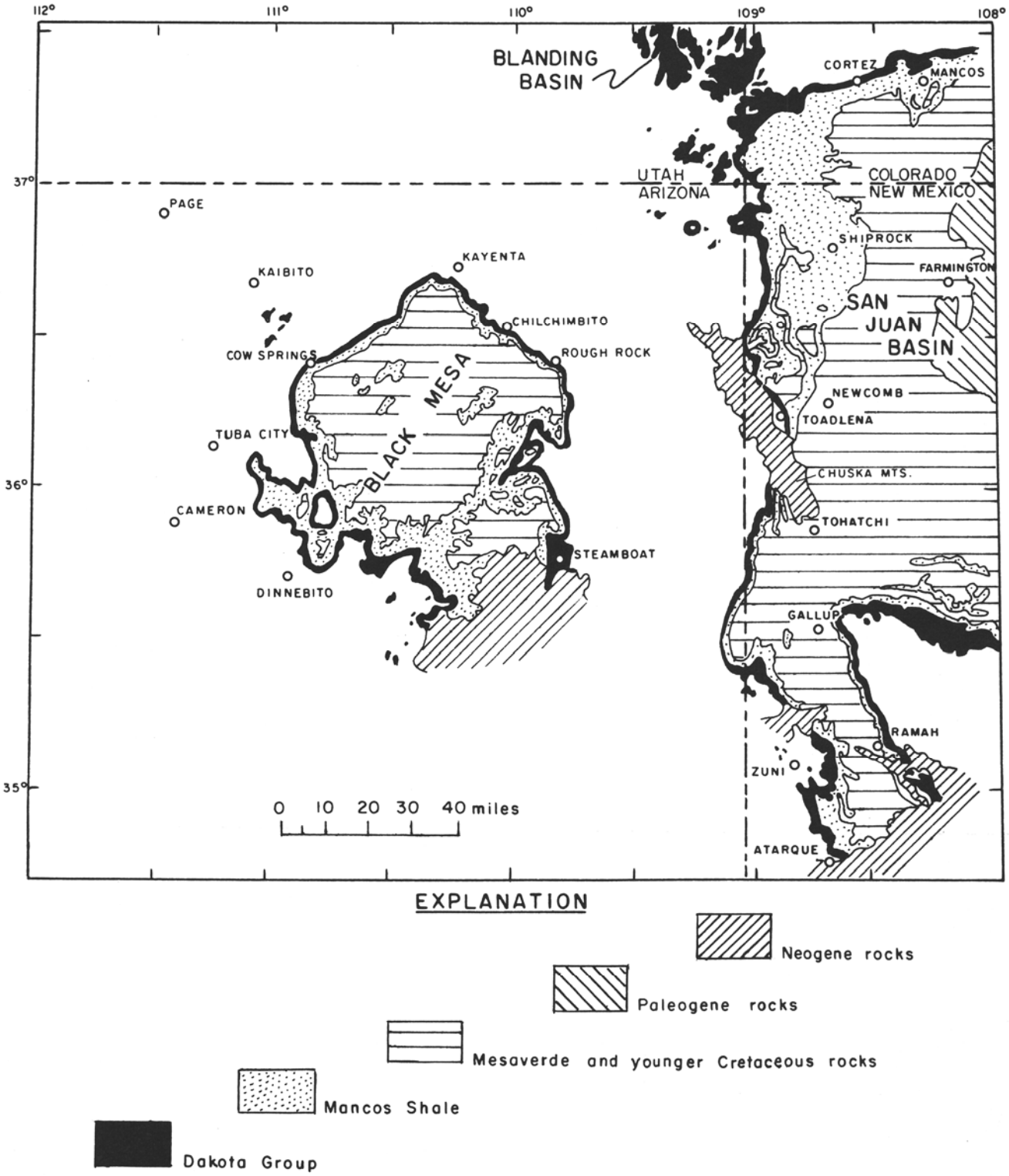

Figure 1.
Distribution of Cretaceous outcrops in the Four Corners area.

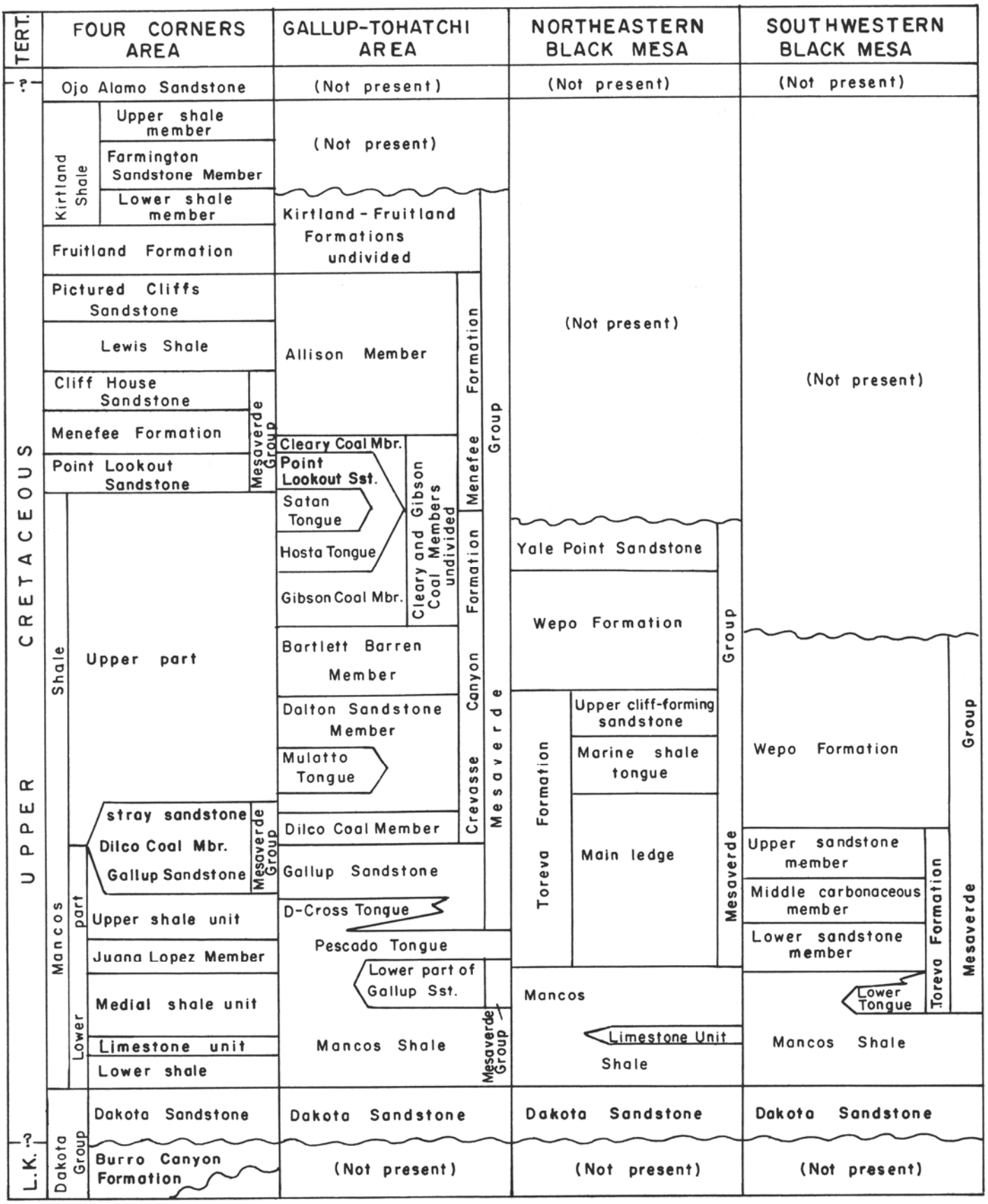

Figure 2.
Cretaceous terminology of the Four Corners area.

products of interchannel and meandering channel subenvironments. In many places the mudstone contains numerous thin lenses or nodules of limestone formed in a poorly defined lacustrine subenvironment.

In the Four Corners area, outcrops of Burro Canyon are identified only along the southern margin of the Blanding basin in a narrow band extending eastward from the southern tip of White Mesa just north of Bluff, Utah, to McElmo Creek near the Colorado-Utah boundary. From here the formation can be traced southward nearly to the San Juan River where it disappears by truncation beneath the basal unit of the Dakota Sandstone. Just how much farther southwestward the Burro Canyon formerly extended is not known but it could well have been a hundred miles or more. Eastward it can be traced intermittently by well logs across the northern portion of the San Juan basin to outcrops in the Chama basin. In this area thicknesses range from 0 to 110 feet but average about 60 feet.

Fossils collected from the Burro Canyon at various localities include freshwater invertebrates, dinosaur bones and plants. None are truly diagnostic but all suggest an Early Cretaceous (Aptian) age.

Dakota Sandstone

The Dakota Sandstone, named by Meek and Hayden (1862) for exposures in northeastern Nebraska, is present in all three basins included in the Four Corners area. Where the Burro Canyon is present the Dakota Sandstone rests disconformably on it but south of the San Juan River the Dakota becomes the basal unit and lies unconformably on progressively older truncated rocks toward the southwest. In many localities a threefold lithologic sequence is present. It consists of a basal conglomeratic sandstone with an underlying disconformity, a middle unit of carbonaceous shale and coal, and an upper unit of evenly-bedded sandstone which intertongues with the overlying Mancos Shale. These strata are deposits of transitional environments which accompanied the westward transgressing Mancos sea (Young, 1973). The basal conglomerate represents a floodplain braided channel deposits which continue into the adjacent paludal environment. The carbonaceous shales are partly paludal but most formed in lagoon ponds, tidal flats and tidal channels of the lagoonal environment just seaward of the paludal belt. The evenly-bedded sandstone was formed at the shoreline as a mainland or barrier beach deposit of the littoral marine environment.

Outcrops of the Dakota Sandstone form a relatively broad dendritic pattern along the southern margin of the Blanding basin north of the San Juan River. It forms a narrower band southward along the west side of the San Juan basin to the Atarque, N. Mex., area. The only gap is one of eleven and a half miles at the southern end of the Chuska Mountains. In the Black Mesa basin, Dakota outcrops almost completely encircle Black Mesa, the only break being a covered area at the south end.

Thicknesses of the formation range from as little as 36 feet on the west side of Black Mesa, to 20 feet near Grants, N. Mex., to as much as 161 feet near Window Rock and 175 feet just east of the Four Corners. Variations appear to be due largely to a brief period of erosion following differential warping in early Greenhorn time.

Faunal evidence summarized by O'Sullivan and others (1972) indicates that the lower part of the Dakota Sandstone is of Early Cretaceous age and the upper part is of Late Cretaceous age, as illustrated in Figure 3.

Mancos Shale

Overlying the Dakota Sandstone is the Mancos Shale named by Cross and Purington (1899) from exposures near Mancos, Colo. It is exposed along the southern margin of the Blanding bairn in a band which joins at the eastern end with continuous exposures along the northwestern and western margins of the San Juan basin. These outcrops are separated by about 40 miles from the continuous outcrops around Black Mesa.

The Mancos consists of evenly-bedded, light to medium dark gray, calcareous marine shale which weathers yellowish gray. It was deposited in nearshore and offshore neritic subenvironments of the Late Cretaceous sea during its overall southwestern transgression and subsequent northeastward regression.

Thicknesses of the Mancos vary from about 2000 feet near Cortez, Colo., to about 475 feet at Blue Point, southwest of Black Mesa. This southwestward thinning is due to intertonguing between the Mancos and the underlying Dakota and between the Mancos and the overlying Mesaverde as shown in Figure 3.

In this area O'Sullivan and others (1972) separated the Mancos into an upper and a lower part. The line of separation is the widespread Gallup Sandstone tongue of the Mesaverde. They further subdivided the lower part into five units as fcllows:

1). A lower shale unit consisting of medium-dark-gray to nearly black shale interbedded with thin layers of sandstone and resting on the Dakota Sandstone. It is present in all three basins and contains fairly abundant fossils of four faunal zones within the Greenhorn Limestone of the western interior reference section (Cobban and Reeside, 1952). These are, from the base upward the *Gryphaea newberryi, Dunveganoceras conditum, Sciponoceras gracile* and *Inoceramus labiatus* zones of the Greenhorn Limestone.

2). An argillaceous greenish-black limestone unit with interbedded calcareous mudstone, commonly referred to as the Greenhorn Limestone. It is generally about 15 feet thick and carries fossils of the *Inoceramus labiatus* zone.

3). A medial shale unit consisting of dark gray silty claystone with some bentonitic claystone beds. The upper 50 feet of the unit is sandy and it grades upward into the Juana Lopez Member in the San Juan basin and the Toreva Formation in the Black Mesa basin. In the Gallup area it is overlain directly by the upper shale unit. In most places the medial shale contains fossils of the *Inoceramus labiatus, Collignoniceras woollgari* and *C. hyatti* zones of the Carlile Shale.

4). The Juana Lopez Member about 500 feet above the top of the Dakota Sandstone. It consists mostly of shale with numerous thin sandy and silty limestone beds. Fossils common here are those of the zones of *Prionocyclus macombi* and *P. wyomingensis* of middle and upper Carlile age. It averages about 35 feet thick and commonly forms a low escarpment.

5). An upper shale unit about 200 to 250 feet thick and somewhat sandier than the medial unit. It is present in the San Juan basin but in the Black Mesa area its time equivalent is the lower part of the Mesaverde Group. An *Inoceramus* species is the only common fossil in this unit.

The upper part of the Mancos Shale, that part above the

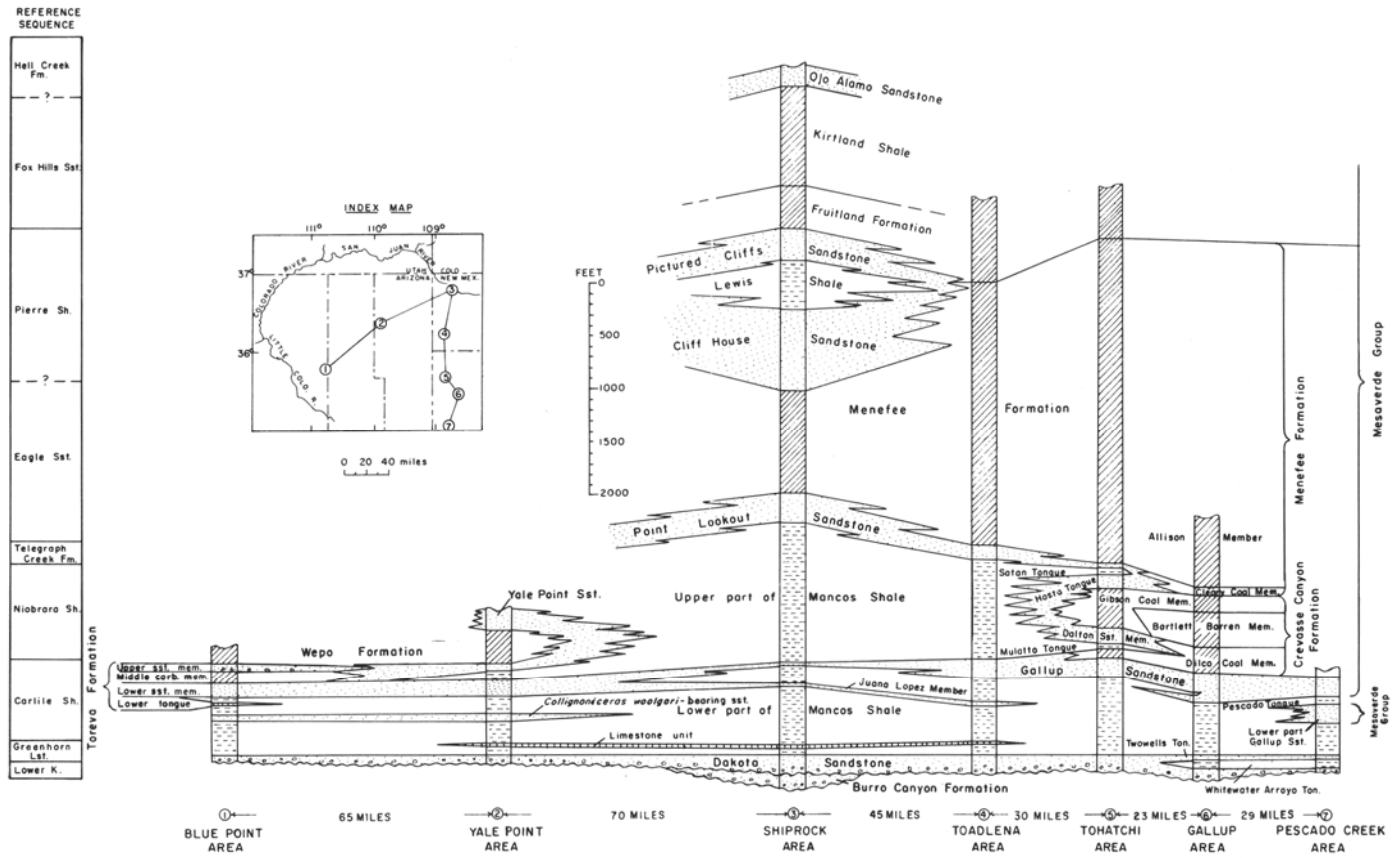

Figure 3.
Correlation of Cretaceous strata of the Four Corners area. Data modified from O'Sullivan and others, 1972.

Gallup Sandstone, is best developed in the San Juan basin. It is composed almost entirely of gray to brownish-gray shale with a few thin sandy zones and numerous zones of limestone concretions. It represents a minor transgression following the Gallup regression and contains lenticular sandstone bodies at the base which mark the position of a strong unconformity (Molenaar, 1973). In places it truncates as deep as the Juana Lopez. This part of the Mancos is about 1400 feet thick near Shiprock, N. Mex., but thins southeastward by intertonguing with the Mesaverde Group. The upper part has been removed by erosion in the Black Mesa area but in the Shiprock-Cortez area it is overlain by the Point Lookout Sandstone of the Mesaverde. Two prominent tongues of this part of the Mancos have been named in the San Juan basin. The Mulatto Tongue (Hunt, 1936) lies between the Dilco Coal Member and the Dalton Sandstone Member of the Crevasse Canyon Formation, and the Satan Tongue (Sears, 1934) lies between the Point Lookout Sandstone and the Hosta Tongue of the Point Lookout.

The upper Mancos is mostly Niobrara in age but the upper 435 to 500 feet along the San Juan River is probably of Telegraph Creek age (O'Sullivan and others, 1972).

Mesaverde Group

In the southern and southwestern portions of the area the Mesaverde Group occurs much lower stratigraphically than in the more seaward area to the northeast where it has thinned at the base by intertonguing with the Mancos. Outcrops in the Black Mesa and San Juan basins are separated by about 40 miles and here discussed separately.

Mesaverde Group in Black Mesa Basin

The Mesaverde Group of the Black Mesa basin is all older than the type Mesaverde of southwestern Colorado and is essentially equivalent to the Gallup Sandstone and Crevasse Canyon Formation of the Gallup area. In the Black Mesa basin, Repenning and Page (1956) subdivided the Mesaverde into three units which are, from the base upward, the Toreva Formation, the Wepo Formation and the Yale Point Sandstone.

In the southern half of Black Mesa the Toreva consists of three units: a basal littoral marine sandstone up to 130 feet thick; a medial lagoonal-paludal unit of carbonaceous mudstone, siltstone and coal averaging about 100 feet; and an upper fluvial conglomeratic sandstone unit as much as 80 feet thick. In the northern half of the mesa the middle unit is replaced by littoral marine sandstone and the three sandstones combine to produce a massive sandstone as much as 275 feet thick. Overlying the massive sandstone is a tongue of Mancos Shale as much as 90 feet thick which grades upward into another cliff forming littoral sandstone which may reach a thickness of 80 feet. Fossils indicate the Toreva is mostly of middle and late Carlile age (O'Sullivan and others, 1972).

The Wepo Formation consists of 300 to 750 feet of siltstone, mudstone, sandstone and coal. The presence of much carbonaceous material, as well as other features, indicates a floodplain paludal-lagoonal origin for this unit. The Wepo thins northeastward as the result of intertonguing with littoral marine deposits of the underlying Toreva and the overlying Yale Point. Its general equivalents in the San Juan basin in-

elude the Crevasse Canyon Formation and the Gallup Sandstone. The Wepo is largely of early Niobrara age.

The Yale Point Sandstone is a massive littoral marine sandstone which lies above the Wepo in a narrow belt along the northeast side of Black Mesa. Here along its landward margin it rests with slight disconformity on the Wepo and also intertongues southwestward with it. It reaches a maximum thickness of about 380 feet and normally is composed of coarse to fine-grained subrounded quartz. However, in places it contains thin silty units as the result of intertonguing with the Wepo. It is the youngest Mesaverde unit preserved in Black Mesa basin and its upper surface is one of recent erosion. It is of Niobrara age and is believed to be the correlative of the Hosta Tongue of the Point Lookout Sandstone (O'Sullivan and others, 1972).

Lower Part of Mesaverde Group in San Juan Basin

The lower part of the Mesaverde of the southwestern flank of the San Juan basin consists almost entirely of nonmarine rocks which, when traced north and northeast, intertongue with and are gradually replaced by neritic shales of the Mancos. Units recognized are the Gallup Sandstone, which extends northward almost to the San Juan River, and the overlying Crevasse Canyon Formation.

The Gallup Sandstone (Sears, 1925), crops out in a nearly continuous band along the west side of the San Juan basin. The only break is an eleven and one-half mile gap where it is buried by Tertiary rocks of the Chuska Mountains. South of the gap it consists of coarse-grained sandstone interbeded with shale, carbonaceous shale and conglomerate totaling 160 to 450 feet. These sediments formed in paludal, lagoonal-estuarine, deltaic and littoral environments. It grades downward into and intertongues laterally with the Mancos and is overlain conformably by the Dilco Coal Member. North of the gap the Gallup consists of about 20 to 50 feet of massive fine grained sandstone and is overlain by 15 to 25 feet of shale of the Dilco. Immediately overlying the Dilco is a 10 to 45 foot slabby coarse-grained sandstone known as the "stray sandstone" of Sears, Hunt and Hendricks (1941). The "stray sandstone" is now believed to have formed during the early Niobrara transgression. Traced northward the Gallup and Dilco grade into the Mancos just south of the San Juan River by the "stray sandstone" continues northward into Colorado. Fossil data indicate that the Gallup ranges in age from early Carlile to possibly earliest Niobrara (O'Sullivan and others, 1972).

The Crevasse Canyon Formation (Allen and Balk, 1954) includes all sedimentary units between the top of the Gallup and the base of the Point Lookout Sandstone in the area south of the Chuska Mountains. In the Gallup area it is entirely nonmarine and can be divided into three units which are, in ascending order: the Dilco Coal Member, a paludal-lagoonal unit consisting of 240 to 300 feet of sandstone, carbonaceous shale and coal; the Bartlett Barren Member of floodplain origin, consisting of 330 to 440 feet of similar rocks without economic coals; and the undivided Cleary and Gibson Coal members consisting of 180 to 280 feet of coal-bearing lagoonal-paludal strata. The Cleary, where separable to the north, is placed in the overlying Menefee Formation. A few miles north of Gallup a persistent littoral marine sandstone, the Dalton Sandstone Member, replaces the upper part of the Dilco. In most places it ranges from 100 to 125 feet thick. Toward the northeast it is split by the Mulatto Tongue of the Mancos and the lower portion pinches out in a short distance. The diachronous upper tongue rises in the section toward the northeast and effectively replaces the Gibson while intertonguing seaward with the Mancos. North of Toadlena, N. Mex., the Dalton has entirely replaced the Gibson and has merged with another littoral marine sandstone which is believed to be the Hosta Tongue of the Point Lookout Sandstone. Overlying this combined unit is the Satan Tongue of the Mancos. Fossils have not been identified from the Crevasse Canyon Formation but stratigraphic relations suggest that it spans much of Niobrara time.

Upper Part of Mesaverde Group in San Juan Basin

As used in this report, the upper part of the Mesaverde Group includes those units first defined as the Mesaverde Group by Holmes (1877). It is entirely confined to the San Juan basin and is best exposed in the type area along the southern edge of Mesa Verde where it consists, in ascending order; the Point Lookout Sandstone, the Menefee Formation and the Cliff House Sandstone.

The Point Lookout Sandstone (Collier, 1919) consists of two or more massive littoral marine sandstone units separated by thin beds of sandy shale. It ranges up to 250 feet thick and grades downward into and intertongues with the Mancos Shale as it climbs in time toward the northeast. The upper contact is commonly sharp but may contain some thin layers of carbonaceous shale of the Menefee which was forming in swamps and lagoons behind the beach. East of Gallup the Point Lookout is split into two parts by the Satan Tongue of the Mancos. Originally they were referred to as the upper and lower Hosta (Sears, 1934), but the upper portion is now correlated with the Point Lookout and the lower part is referred to as the Hosta Tongue of the Point Lookout Sandstone (Allen and Balk, 1954; Beaumont and others, 1956). The Hosta Tongue ranges up to 100 feet thick and consists of a series of regressive sandstone beds which progressively overlap each other southwestward (landward) and served as barriers behind which the upper part of the Gibson Coal Member was formed. Fossils suggest the Point Lookout is of Eagle Sandstone or Telegraph Creek age (Reeside, 1924; Pike, 1947).

Overlying the Point Lookout Sandstone is the Menefee Formation of nonmarine origin. It consists of 400 to 3000 feet of sandstone, shale and coal formed in floodplain, swamp and lagoonal environments. It is coal-bearing at both top and base but the central portion of floodplain origin is essentially barren of coal. The lower coal-bearing unit is locally called the Cleary Coal Member and the middle unit is the Allison Member (Beaumont and others, 1956). The upper coal-bearing member is unnamed. The base of the formation rises stratigraphically toward the northeast as the result of intertonguing with and replacement by the Point Lookout Sandstone, but the top of the formation rises stratigraphically toward the southwest by intertonguing with the Cliff House Sandstone. The result is a wedge thickening toward the southwest. O'Sullivan and others (1972) indicate that in places the base of the Menefee may be as old as Niobrara and that in other places the top may include deposits of Fox Hills age.

The Cliff House Sandstone is the uppermost unit of the Mesaverde Group of the type locality. Named by Collier (1919) it is a massive fine-grained littoral marine sandstone unit with a few lenses of silt and shale representing tongues of the overlying Lewis Shale and underlying Menefee Formation.

As noted above, it rises stratigraphically toward the southwest reflecting an intermittent transgression of the sea in that direction. In spite of the intertonguing at top and base it maintains a thickness of about 600 feet throughout much of the outcrop area but gradually thins southwestward to near Newcomb, N. Mex., where the Lewis Shale pinches out and the overlying Pictured Cliffs Sandstone rests directly on the Cliff House Sandstone. The Cliff House is probably of middle and late Pierre age.

Lewis Shale

Conformably overlying the Cliff House is the Lewis Shale, a southwestward thinning wedge of marine shale named by Cross, Spencer and Purington (1899). This gray claystone and siltstone unit thins from a maximum of about 400 feet near the San Juan River to the pinchout described near Newcomb. It formed in an offshore environment as the Late Cretaceous sea made its final landward encroachment and subsequent withdrawal across this portion of the geosyncline. The Cliff House Sandstone represents the shoreline deposits formed during the advance and the Pictured Cliffs Sandstone represents similar deposits formed during the retreat; consequently, the Lewis intertongues with and grades into both sandstone units. According to Cobban (O'Sullivan and others, 1972) the Lewis is entirely of Montana age extending from the zone of *Baculitis mclearni* up into the zone of *Didymoceras cheyennense* (Gill and Cobban, 1965).

Pictured Cliffs Sandstone

The Pictured Cliffs Sandstone (Holmes, 1877; Reeside, 1924), where best developed near the San Juan River, consists of about 300 feet of interbedded fine to very fine-grained sandstone and gray silty shale with the sandstone beds becoming more massive toward the top. It thins rapidly southward to its pinchout near Newcomb. Because it represents the beach deposits of a regressing shoreline it tends to rise stratigraphically toward the northeast at the expense of the lagoonal-paludal deposits of the Fruitland Formation which formed landward from the beach. As a result the Pictured Cliff Sandstone intertongues landward with the Fruitland Formation and grades seaward and intertongues with the Lewis Shale. Fossil evidence indicates the Pictured Cliffs is of middle Montana age ranging from the zone of *Didymoceras cheyennensis* up to the *Baculitis compressus* zone (Gill and Cobban, 1965).

Fruitland Formation

Conformably overlying the Pictured Cliffs Sandstone near the San Juan River is the Fruitland Formation named by Bauer (1917) for exposures near the town of Fruitland, New Mex. It consists of a variable sequence of sandstone, siltstone, mudstone and coal. Because of its carbonaceous nature it is believed to have formed in lagoonal-paludal and possibly floodplain environments. The lower contact of the formation is one of gradation into and intertonguing with the Pictured Cliffs. The upper contact with the Kirkland Shale is also gradational and is arbitrarily placed at the top of the highest persistent sandstone bed. Thicknesses range from 275 to 420 feet with a general thinning toward the south.

In the Chuska Mountain area between Toadlena and Tohatchi a sequence of rocks were mapped as Kirtland and Fruitland formations undivided by Zieglar (1955). They are equivalent to the Fruitland Formation and Kirtland Shale farther northeast but because of the absence of the Cliff House Sandstone, Lewis Shale and Pictured Cliffs Sandstone they rest directly on the Menefee Formation. The entire sequence is about 800 feet thick near Toadlena.

The age of the Fruitland was long a point of discussion but most workers now agree that it is upper Pierre-lower Fox Hills age (Cobban and Reeside, 1952).

Kirtland Shale

The Kirtland Shale, which conformably overlies the Fruitland Formation, was named by Bauer (1917) for exposures near the town of Kirtland, New Mex. It consists of lower and upper shale members separated by the Farmington Sandstone Member (Bauer, 1917).

The lower shale member ranges from 310 to 1000 feet thick and consists of greenish gray mudstone with thin lenses of fine grained sandstone. The Farmington Sandstone Member is composed of interbedded sandstone, siltstone and mudstone and ranges in thickness from 90 feet to more than 450 feet. The upper shale unit closely resembles the lower unit but contains a few thin bands of purple to dark gray mudstone. North of the San Juan River abundant siliceous pebbles occur in the upper part of the member (Barnes and others, 1954; Hayes and Zapp, 1955). Thicknesses of the upper member range from 90 to 475 feet.

Most of the Kirtland appears to be of floodplain origin, however, the discovery of poorly preserved shallow marine or brackish water foraminifera in the middle of the Farmington Sandstone (Dilworth, 1960) suggests a possible short-lived invasion of the sea at that time. Another possibility is that these fossils were reworked by streams during Farmington time. Cobban and Reeside (1952) considered the Kirtland to be equivalent to the upper Pierre and lower Fox Hills of the standard section.

Ojo Alamo Sandstone

A controversial unit in the San Juan basin is the Ojo Alamo Sandstone, a sequence of sandstone, shale and conglomerate that crops out along Ojo Alamo arroyo. Most of the controversy has arisen from the fact that the formation was originally poorly defined and that the Mesozoic-Cenozoic boundary occurs within, just above, or just below it.

Since its definition by Brown (1910) as a dinosaur bearing shale the formation has been: (1) expanded to include three overlying units (Sinclair and Granger, 1914); (2) restricted to the three overlying units (Bauer, 1917); (3) considered Tertiary in age (Reeside, 1924); (4) reclassified as Cretaceous (Dane, 1936); (5) still further restricted to the uppermost of the three overlying units (Ojo Alamo Sandstone "restricted") and labeled Paleocene (Baltz, Ash and Anderson, 1966); and (6) suffered many other indignities at the hands of would-be classifiers. The most recent work (Powell, 1973) records the discovery of dinosaur bones 20 feet above the base of the Ojo Alamo Sandstone "restricted." Powell believes that the upper part of this unit is Paleocene and calls for new names for strata in this interval.

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