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# *Mesozoic stratigraphy of south-central New Mexico*

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# MESOZOIC STRATIGRAPHY OF SOUTH-CENTRAL NEW MEXICO

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## INTRODUCTION

Little detailed work has been published on the Mesozoic stratigraphy of south-central New Mexico, but such work as has been published has been drawn on freely for this article. The following discussion is limited mainly to the area around the Jornada del Muerto since outcrops in the Iron Mountain area west of the Rio Grande have not been studied in detail. It is difficult to reconstruct the Mesozoic sedimentary history of the region due to the fact that only isolated outcrops are found. These few outcrops are badly faulted and eroded so that a complete sequence of Mesozoic beds is seldom seen in any one section. Much of the Mesozoic section that was originally present has been removed by erosion in the mountain ranges, but it is preserved in at least some of the "basins" of the Basin abd Range province. For this reason the character and original distribution of the Mesozoic rocks is of interest. The thickest known section of Mesozoic or questionably Mesozoic rocks, that at the north end of the Caballo Mountains, may be more than 6,000 feet thick.

During the early part of Mesozoic time south-central New Mexico was apparently a part of a geanticline (Silver, 1948). As a result, the nonmarine Triassic and Jurassic rocks pinch out toward the south on the highland, and the marine Lower Cretaceous rocks pinch out toward the north. This pattern of thin or absent sedimentation in south-central New Mexico changed abruptly with the advent of Upper Cretaceous time when deposition of geosynclinal proportions began. This rapid Upper Cretaceous deposition apparently continued into Tertiary time without a major break at the Cretaceous-Tertiary time line. The lower part of the Upper Cretaceous section is marine, but the upper part is mainly terrestrial. The latest Cretaceous rocks differ from the older part of the Mesozoic section in that they contain a considerable amount of volcanic material. This volcanism was probably associated with the Laramide orogeny.

## TRIASSIC ROCKS

Triassic rocks overlie the Permian San Andres formation with marked unconformity. In the Carthage area, at the north end of the Jornada del Muerto, the Triassic section is called the Dockum formation (Wilpolt and Wanek, 1951), and that name is used here for the redbed section encountered between the Dakota and San Andres in the Sun Oil Company Victorio Land and Cattle Company Nos. 1 and 2 wells drilled in T. 10 S., R. 1 W. in the northern Jornada del Muerto.

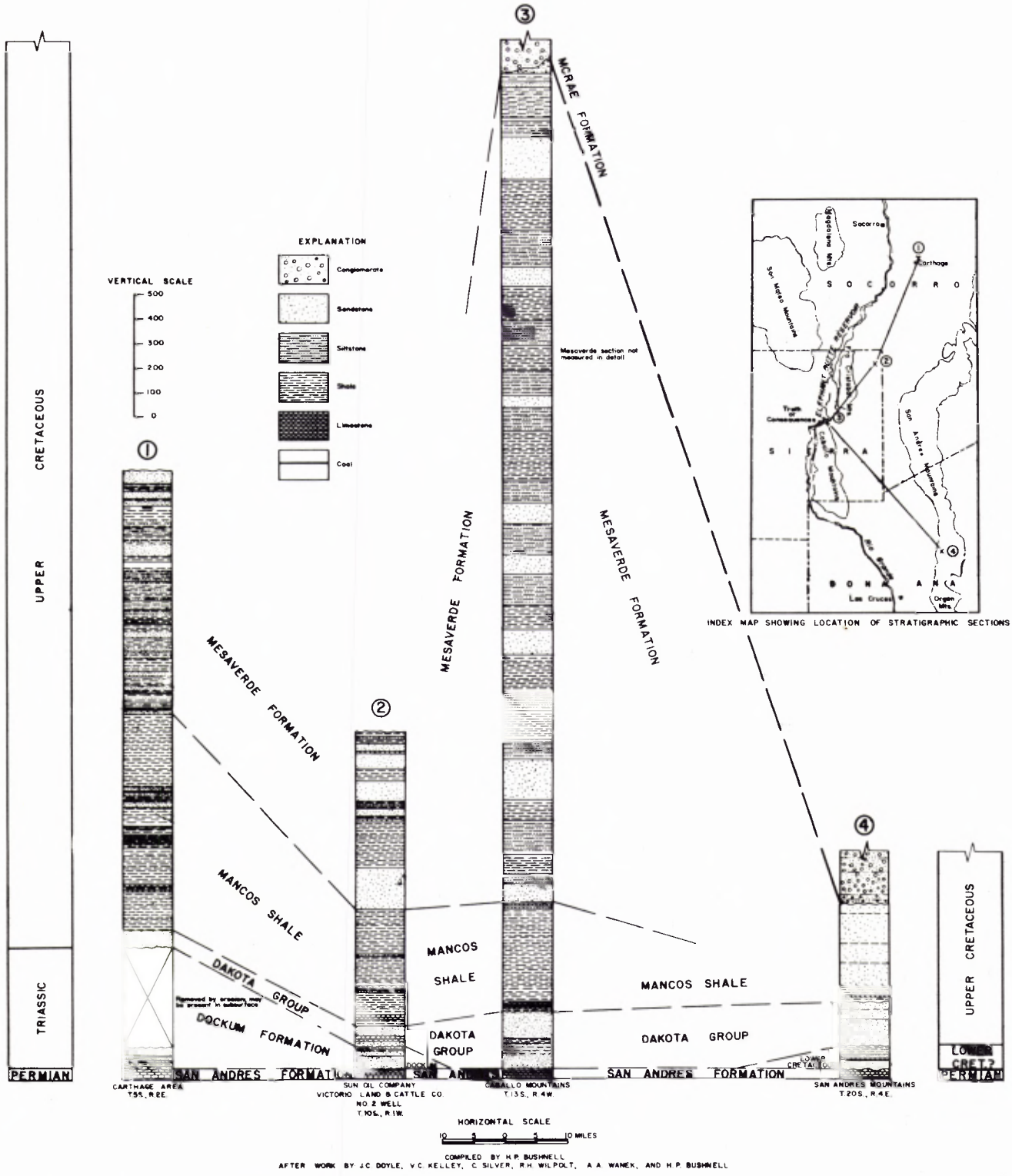
The Dockum beds crop out near Carthage and on the west flank of the northern part of the San Andres Mountains. The relatively thin section in the Sun Oil Company wells is probably near the southern edge of the Triassic rocks in the Jornada del Muerto since none have been reported at the south end of the Fra Cristobal Mountains or in the Caballo Mountains. Outcrops of Triassic rocks are present in the Three Rivers area of the Tularosa Valley and north of Magdalena, to the west of the Rio Grande Valley. In general, the Dockum formation consists of red, purple, or light-gray shale, siltstone, and sandstone beds, but local limestone conglomerate beds are also present. Purple shades dominate the color of the formation.

The northwest thickening of the Dockum formation from the pinch out is relatively rapid. In the Sun Oil Company Victorio Land and Cattle Company No. 2 well (Fig. 1) the Triassic section is about 90 feet thick , and in the Carthage area the section is probably about 500 feet thick, although because of complex structure it is difficult to measure a complete section. Near the Lucero uplift the section is more than 1,000 feet thick (Wengerd, 1950). The postulated southern limit of the Triassic is shown on the accompanying figure (Fig. 2).

Correlatives of both the Chinle formation and the Santa Rosa sandstone are probably present in the Dockum. The Lobo formation, which crops out in the Florida Mountains and in Cooks Range, was originally considered to be Triassic (?) in age (Darton, 1916), but geologists who have worked in the region more recently generally agree that the Lobo formation is either of Permian or Cretaceous age. Some of the outcrops originally mapped as Lobo may be of Cretaceous age and others of Permian age.

## LOWER CRETACEOUS ROCKS

The Lower Cretaceous section is probably the most neglected part of the stratigraphic sequence in southern New Mexico. This is undoubtedly due to




MESOZOIC STRATIGRAPHIC SECTIONS IN SOUTH-CENTRAL NEW MEXICO

Figure 1

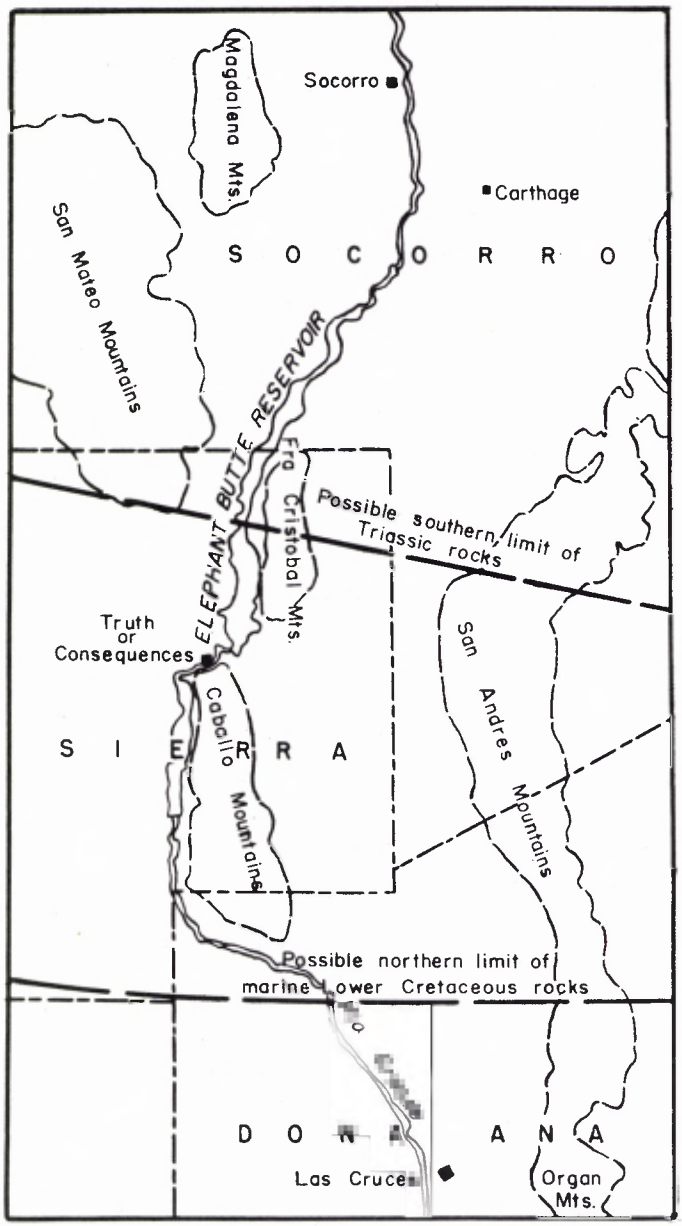



Figure 2. Map of south-central New Mexico showing the postulated pinch-outs of the Triassic and marine Lower Cretaceous rocks. Non-marine Lower Cretaceous rocks may be present farther north.

the fact that exposures are widely scattered and much faulted. A thin interval that may be of Lower Cretaceous age is present near the south end of the San Andres Mountains, and Lower Cretaceous rocks are known near El Paso, Texas and in the East Potrillo Mountains in southern Dona Ana County. Outcrops are also present near Silver City in western New Mexico where they were called the Sarten sandstone by Darton (1916). Not enough work has yet been done to ascertain the former distribution and correlation of the Lower Cretaceous rocks in this region. The possible northern extent of the Lower Cretaceous rocks in south-central New Mexico is shown on Figure 2, but in the Caballo Mountains, the Dakota group as described by Kelley and Silver (1952) seems to be abnormally thick. Here it increases to 245 feet in thickness from about 80 feet in the Sun Oil Company No. 2 well to the north and about 180 feet near the south end of the San Andres Mountains. The lower part of this thicker section of so-called Dakota in the Caballo Mountains does not resemble the Dakota in other areas and it may well be of Lower Cretaceous age.

The Lower Cretaceous sequence in south-central New Mexico consists of sandstone, sandy limestone and conglomerate beds while farther south in the El Paso area the section consists mainly of marl, limestone, and shale beds. The limestone is used extensively in the manufacture of cement at El Paso. The clastic contents of the Lower Cretaceous section seems to increase toward the north, and this increase may indicate an approach to an ancient shore line in that direction. Near the Lucero uplift there is a black shale between the Jurassic Morrison formation and the Dakota group that contains plant fragments. This zone may be Lower Cretaceous.

## UPPER CRETACEOUS ROCKS

The Upper Cretaceous stratigraphic section in south-central New Mexico is usually divided into three main units. They are, in ascending order, the Dakota group, the Mancos shale, and the Mesaverde formation. The McRae formation, which overlies the Mesaverde formation in parts of the region with marked unconformity, is considered to be partly Upper Cretaceous and partly Tertiary in age and is included in this discussion. The exact location of the line of the Cretaceous system has not been determined since no fossils have been found in the upper part of the McRae formation.

### Dakota Group

The rocks of the Dakota group crop out rather widely in the north end of the Jornada del Muerto

near Carthage, in scattered patches on the west flank of the San Andres Mountains, in several small outcrops at the south end of the Fra Cristobal Mountains and in a narrow outcrop along the east side of the Caballo Mountains. Outcrops are also found near Three Rivers on the east side of the Tularosa Valley.

The Dakota rests on San Andres, Dockum, or Lower Cretaceous beds in different areas. It usually forms resistant ridges between the softer beds below and Mancos shale above. The Dakota group varies in thickness from about 70 feet to 110 feet in the Carthage area at the north end of the Jornada del Muerto to 245 feet in the Caballo Mountains. In the Caballo Mountains there is a lower, white siltstone unit 26 feet thick, but above that unit the Dakota resembles the rocks in other parts of New Mexico generally referred to the Dakota. This upper unit is mainly medium- to coarse-grained quartose sandstone in which there are a few thin gray shale beds. It is usually white on a fresh fracture but locally weathers pink. In the Caballo Mountains the upper foot of the Dakota section consists of a dark-brown, very coarse-grained, cross-bedded sandstone containing pebbles. Locally, there is a black shale at the base of the Dakota. Kelley and Silver (1952) reported that some of the sandstone beds in the upper part of the section in the Caballo Mountains are locally impregnated with bituminous matter.

The Dakota group, as seen in south-central Mexico. The group also resembles the Beartooth quartzite in the Silver City area to the west. The Beartooth quartzite is now classed as Upper (?) Cretaceous by geologists who have worked in that area (Hernon, Jones, and Moore, 1953), although it was considered to be of Lower Cretaceous age by some earlier workers. The Dakota group of south-central New Mexico may also be correlative with the Woodbine sandstone of Texas.

### Mancos Shale

The Mancos shale crops out in scattered areas mainly on the flanks of the mountain ranges in south-central New Mexico. Around the edges of the Jornada del Muerto outcrops are found near Carthage, at the south end of the Fra Cristobal Mountains, on the west flank of the Caballo Mountains and in scattered patches on the west edge of the San Andres Mountains. In general, the Mancos is not very resistant to erosion, and as a result, it is frequently covered by debris, but excellent outcrops are found in some stream valleys.

In the Carthage area the Mancos shale consists mainly of gray, friable, calcareous shale and in the upper shale section there are septarian concretions. The Mancos there has a maximum thickness of about 870 feet. The shale includes a lower limestone unit of Greenhorn age and a middle sandstone member (Wilpolt and Wanek, 1951).

In the Sun Oil Company, Victorio Land and Cattle Company No. 2 well drilled in the Jornada del Muerto, between the outcrops at Carthage and those in the Caballo Mountains, the Mancos shale is 480 feet thick. In that well the Greenhorn limestone unit and the middle sandstone member are recognizable although the sandstone is much less conspicuous than at the Carthage outcrops.

In the Caballo Mountains the Mancos shale is 350 to 450 feet thick. Here, the lower limestone unit is present but the sandstone member found at the northern localities is completely absent. Southward from the Caballo Mountains section the Mancos thins abruptly and is very difficult to separate from the overlying Mesaverde beds. Dunham (1935) attributed about 200 feet of section of Benton age in the southern part of the San Andres Mountains to the Mancos shale. This section has not been thoroughly studied, but it is obviously much thinner than the sections to the north. A limestone unit is also present at this outcrop.

Viewed from a regional standpoint the Mancos shale thins from a maximum thickness of more than 800 feet to 200 feet or less from north to south in the Jornada del Muerto. This thinning seems to be due in part to thinning of the shale interval (Graneros?) beneath the limestone unit (Greenhorn?). Kelley and Silver (1952) suggested that this thinning may be due to depositional onlap. In addition to the thinning in the lower Mancos beds the sands of the Mesaverde formation seem to migrate downward in the section toward the south. This could be due to an approach to a source area with a resulting increase in the percentage of coarser clastic material from north to south.

### Mesaverde Formation

The Mesaverde formation was originally very thick and widely distributed in south-central New Mexico, but much of the section was removed by erosion, probably in late Cretaceous and Tertiary time. A thick section is found at the north end of the Caballo Mountains, and almost all of the original thickness may be still present there. That section is more than 3,300 feet thick.

In the Carthage area the top of the Mesaverde is eroded and the section is about 1,000 feet thick. The top of the Mesaverde is also eroded in the Sun wells. At the north end of the Fra Cristobal Mountains there is a small outcrop of the Mesaverde form-

ation. It also crops out rather widely in the Cutter sag between the Caballo and Fra Cristobal Mountains and north of Cutter in the Jornada pediment surface east of the Caballo Mountains. A few small outcrops are found along the southwest flank of the San Andres Mountains and to the east near Three Rivers in the Tularosa Valley. Cretaceous outcrops, which may be correlative with the Mesaverde, are present in the Iron Mountain area west of Truth or Consequences.

The Mesaverde section consists of gray to buff or brown, medium-grained sandstone beds with alternating beds of shale, siltstone, and mudstone. All beds lense within relatively short distances and sandstone beds are seldom more than one and one-half miles in outcrop length. The over-all color of the Mesaverde formation is brown or olive-brown. The shale is commonly gray or green and in some places has a glauconitic or carbonaceous content. The sandstone beds are often massive and cross-bedded with reddish or purplish hues on weathered surfaces in the upper part of the section.

At the north end of the Caballo Mountains, where a very thick section of Mesaverde has been preserved from erosion, the upper 100 to 200 feet contains a zone of coarse-grained sandstone and quartz pebble conglomerate which has been separated from the main body of the Mesaverde formation and called the Ash Canyon member of the Mesaverde formation (Bushnell, 1953). The unit is quite distinctive and contains the coarsest material yet seen in the Mesaverde outcrops in south-central New Mexico. This is probably due to the fact that the upper conglomerate unit has been removed by erosion at most other localities. Blocks of the Ash Canyon member have been widely used in the Elephant Butte Recreation Area in the construction of walls and walks. Much silicified wood is found in the Mesaverde formation, and it is especially conspicuous in the upper Ash Canyon beds. One log about 30 feet long and 3 feet in diameter has been observed in beds east of Elephant Butte Lake. Numerous fossil pelecypod fragments are present in the lower beds of the Mesaverde formation in the Caballo Mountains.

The top of the Mesaverde is everywhere marked by an unconformity, and the formation is overlain in different places by the McRae formation, the Baca formation, the Datil formation, the Santa Fe formation, or by Quaternary alluvium, all of which are truncating formations. The basal contact of the Mesaverde with the underlying Mancos shale is usually transitional.

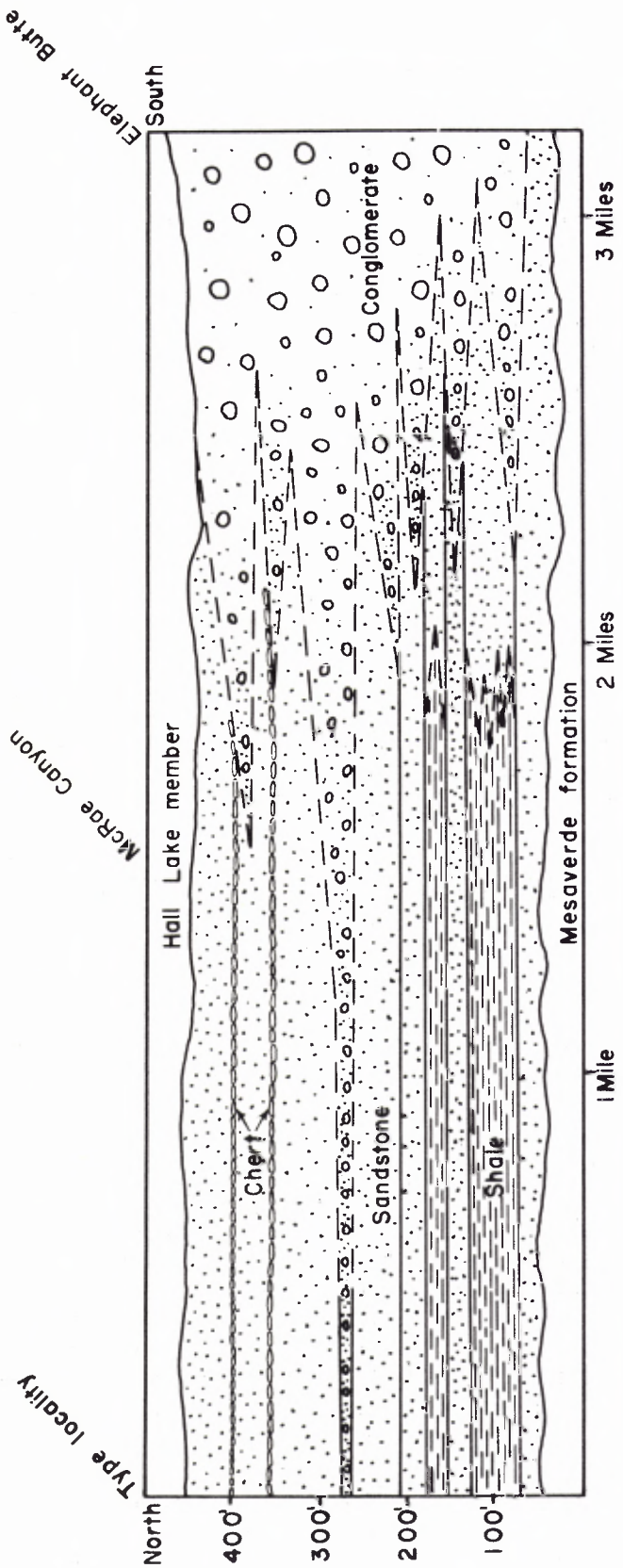
The coal beds are present just above the base of the Mesaverde near Carthage (Wilpolt and Wanek, 1951). The lower or Carthage bed is 5 feet thick and consists of good grade bituminous coal. All of the mines at Carthage mined this bed. The upper bed is thin and contains many shale partings (Gardner, 1910). A considerable amount of coal was mined at Carthage, part of which was used for coking. It was carried first by wagons, then by a railroad which was built and abandoned twice, and finally by truck to San Antonio, where it was carried by railroad to El Paso and to other markets in the southwest. The mines are now closed or are operated only sporadically.

Lignite coal deposits were described by Lee (1905) in the Engle coal field at the north end of the Caballo Mountains. One coal bed about 1 foot thick was prospected, but no commercial seams are known in that area. Numerous pods of coal and some Carbonaceous shale beds are present in the lower part of the Mesaverde section in the Caballo Mountains. At the south end of the San Andres Mountains on the west side of the range an old collapsed coal working in strata equivalent to the Mesaverde or Mancos is visible. This mine was reportedly worked by soldiers stationed at Fort Selden in the Rio Grande Valley during the latter half of the nineteenth century. The coal was apparently low grade and thin, since no extensive mining activity has been reported.

### McRae Formation

The unconformity which separates the Mesaverde from the overlying McRae formation is a truncating one, since in some places the Baca formation, which is probably partly equivalent to the McRae, rests on Triassic rocks. Locally, as in the Elephant Butte Recreation Area, the contact is one of marked angular unconformity, but in other less disturbed areas the beds above and below the unconformity are essentially parallel. In some isolated outcrops it is difficult to distinguish the younger McRae beds from the underlying Mesaverde beds on casual examination. Everywhere where it has been examined carefully, the McRae formation contains fragments of dark volcanic material, whereas none has been seen in the Mesaverde beds.

Although the McRae formation was named by Kelley and Silver (1952), many earlier geologists had mentioned and described briefly the thick sequence of rocks exposed near Elephant Butte. This section consists of several hundred feet of volcanic conglomerate at the base and many hundreds of feet of reddish brown or purple sandstone and shale above. That sequence of beds has been divided into two members (Bushnell, 1953). The lower member, called the Jose




Creek member, includes the volcanic conglomerate beds. The upper or Hall Lake member is made up of the thick section of purple and buff sandstone and shale beds which are well exposed along the shore of Elephant Butte Reservoir.

At the type locality, just north of McRae Canyon east of Elephant Butte Reservoir, the Jose Creek member includes 394 feet of olive drab shale, dark-brown to greenish sandstone, and bedded chert. Farther south near Elephant Butte this section apparently grades into coarse volcanic conglomerate beds. The relations of the two facies of the Jose Creek member cannot be observed because of faults and covering basalt flows, but the apparent relations of the two facies are shown in Figure 3. Southeast of Elephant Butte Reservoir in the Jornada del Muerto the Jose Creek is completely absent and the upper Hall Lake member rests directly on the Mesaverde formation. The conglomerate of the Jose Creek member contains pebbles, cobbles, and boulders of intermediate volcanic rocks along with some cobbles of basalt. In the Elephant Butte Recreation Area boulders of volcanic rock that are as much as 6 feet in diameter may be observed.

A florule collected from the Jose Creek member contains forms which have been tentatively dated as Upper Cretaceous (Bushnell, 1935) and the reported presence of fossil fragments of the Upper Cretaceous dinosaur *Triceratops*, in the overlying member of the McRae formation adds additional weight to this age determination.

The source of the numerous large volcanic boulders in the Jose Creek member presents a very difficult problem when an attempt is made to explain their origin. The boulders are concentrated in local areas. The best known and greatest area of concentration is in the Elephant Butte Recreation Area near Elephant Butte dam. The abrupt lithofacies change from conglomerate to sandstone and shale away from that area, the detrital volcanic material, the chert which may have originated as volcanic ash, and the local distribution of the member along with certain other evidence finally led to the postulation that the Jose Creek member originated largely as a mudflow type of deposit from an intrusive breccia (?) located near the Elephant Butte Recreation Area. There may

Figure 3. Diagrammatic cross section showing the lithofacies in the Jose Creek member of the McRae formation from the type locality of the Jose Creek member southward to the vicinity of the intrusive breccia (?) in the Elephant Butte Recreation Area. Scales are approximate.

have been several other intrusive-extrusive centers in the same general region. Other areas may also have been contributing sediment. The intrusive breccia (?) has not yet been completely studied and additional work may lead to several alternative theories of origin.

In the Jornada del Muerto south of Engle the McRae formation consists almost entirely of purple shale with very few sandstone or conglomerate beds. South of Cutter the Jose Creek member is completely absent and the Hall Lake member rests directly on Mesaverde strata.

Several geologists have reported fossil fragments or a portion of a skeleton of *Triceratops*, the Cretaceous three-horned dinosaur, from what are apparently the lower beds of the Hall Lake member near Elephant Butte (Bushnell, 1953). Palm leaves along with numerous stems and other fragments of plant fossil are indicative of a humid climate in Upper Cretaceous time that must have been a startling contrast with the present arid one.

The Hall Lake member is similar in many respects to the Tertiary Baca and Galisteo formations to the north; therefore it seems possible that the upper part of the McRae formation may be Tertiary in age and the lower part Upper Cretaceous.

Dunham (1935) and others have described conglomeratic beds at the south end of the San Andres Mountains and the west side of the Organ Mountains that unconformably overlie the Paleozoic and Mesozoic rocks but underlie the Tertiary volcanic rocks. This section is mainly conglomerate with a few siltstone beds, and it contains many cobbles and boulders of silicified wood, as does the Galisteo formation in north-central New Mexico. This section is lithologically different from the McRae formation of the Elephant Butte area, but sediments of this type which were deposited during an active tectonic phase should be expected to reflect the lithology of the adjoining uplifts. This would explain the differing lithologies of the two sets of beds.

The upper contact of the McRae formation is everywhere unconformable, and in many of the uplifts and some of the basins of south-central New Mexico the formation is obviously absent. In some areas where the formation is absent, erosion has cut deeply into Mesozoic and Paleozoic rocks. In the Sun Oil Company's wells in the northern Jornada del Muerto, for example, the McRae formation is absent. It is interesting to speculate upon its presence or absence or total thickness in the various parts of the Rio Grande depression and in nearby areas.

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