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## The Zia Sand Formation, New Early to Medial Miocene Beds in New Mexico

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The Zia Sand Formation, herein distinguished and described for the first time, crops out at several localities in the Jemez Creek Valley and in a few of the canyadas along the northern part of the Ceja del Rio Puerco in Sandoval County, New Mexico.

These are the first early Miocene deposits reported from New Mexico for which conclusive fossil evidence for time-unit correlations (Wood *et al.*, 1941) is available. Field work by Frick Laboratory parties, under my direction during 12 seasons since 1946, has resulted in the discovery of fossils at many localities and at many horizons in the Jemez Creek area, the Ceja del Rio Puerco area, and the Gabaldon badlands. The work was a part of the exhaustive investigations of the paleontology, geology, and stratigraphy of the Santa Fe Formation started in 1924 by Dr. Childs Frick and continued until his death in 1965. An extensive report, "The Stratigraphy of the Santa Fe Group," by the author and John C. Blick is now in preparation, and this will deal in great detail with the broader aspects of the geology and stratigraphy of the areas that are described briefly in this preliminary report. Both of these reports are directly the result of Dr. Frick's long-continued interest in the fauna of the Santa Fe beds. It is a pleasure to acknowledge his constant and kindly support. I am indebted to the members of the Frick Laboratory for aid and advice in the preparation of the manuscript and especially to Mr. Raymond Gooris for help with illustrations.

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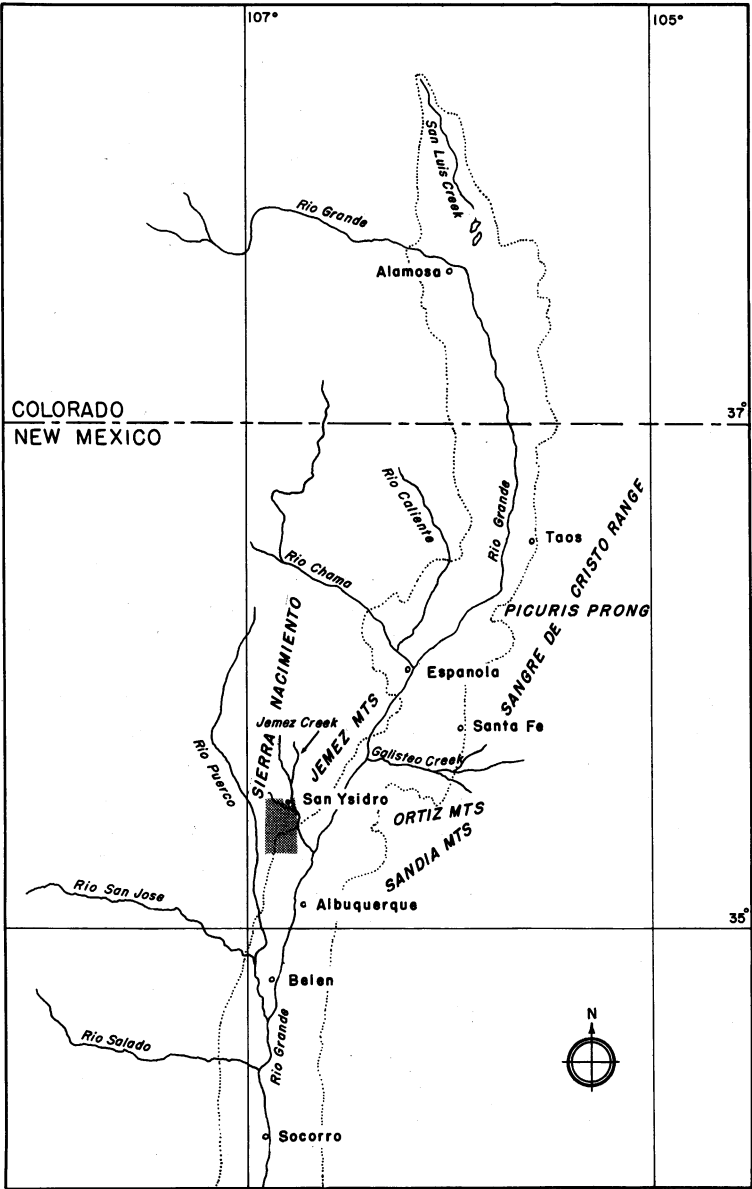


FIG. 1. Index map, showing the location of the type locality of the Zia Sand Formation in New Mexico. Dotted outline shows the Rio Grande depression after Bryan.

In 1947 I discovered the Standing Rock Quarry in Canyada Piedra Parada, a tributary of Jemez Creek south of the town of San Ysidro. This quarry and several extensions of it have yielded a superb collection of the remains of the little, aberrant camel *Stenomylus*, and many remains of *Daphaenodon*, *Cynarctoides*, *Promartes*, Archaeolaginae, and a few rodents. The species of *Stenomylus* and *Daphaenodon* differ very little from those obtained from the Harrison Formation in Nebraska and eastern Wyoming.

The Zia Sand Formation is well exposed in Canyada Piedra Parada, particularly in the East Fork of the canyada (fig. 2). The type area lies west of the Jemez fault in sects. 11, 12, 13, 23, and 24, T. 14 N., R. 1 E., of the New Mexico Principal Meridian in Sandoval County, New Mexico. The formation takes its name from the Zia Indian Pueblo, and the type section is here designated as starting a few yards north of the south line of the NW.  $\frac{1}{4}$  of sect. 11, T. 14 N., R. 1 E., Sandoval County, and is then measured through the Standing Rock Quarry and continued in a southerly to southeasterly direction through sect. 14 and the northern part of sect. 23 (fig. 2).

The Zia Sand is about 1000 feet thick along the line of the type section, which is shown in section A-B of figure 2 and in figure 3. The type area is bounded on the east by the Jemez fault and about 4 to 4½ miles to the west by the Canyada de las Milpas fault (fig. 2). Other outcrop areas of the Zia Sand, not shown on the geologic map (fig. 2), lie east of the Jemez fault in T. 15 N., R. 2 E., Sandoval County. Correlated areas occur north and east of Jemez Creek in the Arroyo Pueblo and Arroyo Chamiso localities in T. 16 N., R. 2 and 3 E., and also in the Canyada Navajo, Canyada Pilaes, and Canyada Moquino areas a few miles south along the Ceja del Rio Puerco in T. 12 and 13 N.

The deposits of the Zia Sand Formation are extremely soft sandstones composed predominantly of slightly cemented medium- to coarse-grained quartz sand. A few thin beds of fine-grained sandstone or siltstone occur in the section, and two calcareous ledges crop out. These calcareous ledges locally show numerous worm borings and worm trails. The sandstones are dominantly light gray, but yellowish gray or pinkish gray bands appear toward the top of the formation. The sandstones are cross-bedded locally, and the cross lamination is usually of the current type, although some eolian shifting is indicated. The rounded, frosted appearance of the sand grains of many beds suggests that the grains have been subjected to greater wind action than is indicated by the amount of cross lamination of the beds at the site of deposition. Resistant, lenticular, calcareous, concretionary sandstones crop out

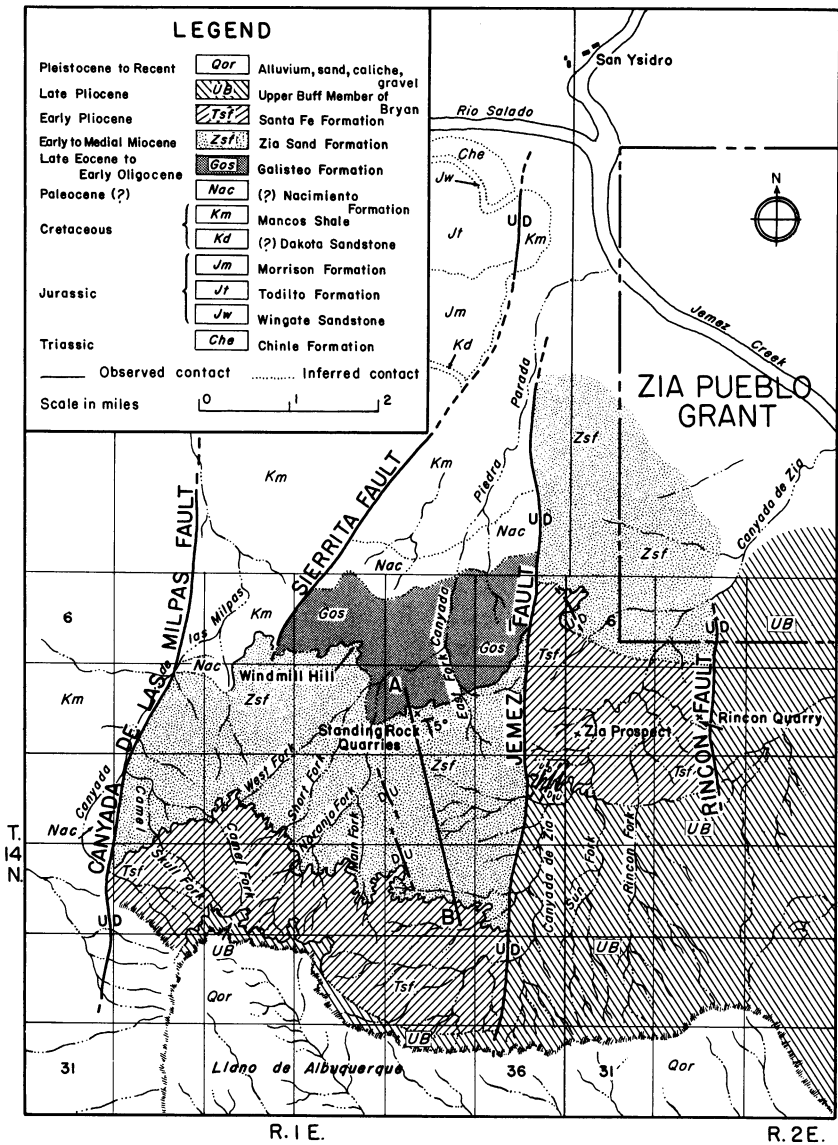


FIG. 2. Geologic map of the type locality of the Zia Sand Formation, Jemez Creek area, Sandoval County, New Mexico. Geology by Ted Galusha.

throughout the formation and locally impart a ribbed appearance to the exposures. Some beds contain large masses of ball-like concretions that in some places are plastered on, and in others are contained in, large, case-hardened, tubular concretions 12 or more feet long. At other spots the concretions are massive and crop out as ledges. Owing to the effects of differential erosion, some concretions cap columns, pedestal rocks, and small buttes. Cross bedding is often best shown by the attitude of the concretionary sandstones. The laminae of the cross beddings are commonly incorporated without distortion in the concretions; therefore, the concretions are classed as epigenetic. Ball-like sand concretions, commonly less than 3 inches in diameter, may be concentrated on slopes and appear to form a greater part of the deposits than is actually the case. A few greenish lenses crop out, and these are commonly closely associated with calcareous layers or fossiliferous strata. Lenses of pebbles are rare.

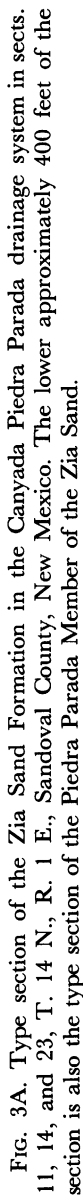
The Zia Sand, on large numbers of outcrops, weathers to relatively smooth sandy slopes, with the windblown debris often masking most of the bedding, and this is especially true of the deposits lying west of the main fork of Canyada Piedra Parada. The type section, in the East Fork, is the only well-exposed section and therefore is the only one that can be measured precisely.

The Zia Sand Formation, in the type locality, unconformably overlies a laminated greenish clay deposit about 30 feet thick that, in turn, conformably overlies Galisteo deposits from which numerous titanite specimens have been collected. Whether or not the laminated clay represents merely the closing phase of the Galisteo Formation, or the time-stratigraphic equivalent of the Gering or Monroe Creek Formations of early Miocene time, or one of the divisions of the White River Oligocene of the Great Plains section will remain for future investigators to decide. The laminated clay is here tentatively regarded as part of the Galisteo deposits.

Contact of the Zia Sand with the underlying deposits is marked by a basal conglomerate on Windmill Hill and at the Standing Rock Quarry locality (see cross section, fig. 3). The conglomerate is commonly composed of sand, pebbles, and small balls of clay.

About 400 feet above the base of the formation is an obscure unconformity that may prove significant in future studies of the stratigraphy in this area. This intermediate unconformity lies at the top of a 100-foot-thick set of coarse gray sand beds characterized by very large concretionary masses and ledges. The sand immediately below the obscure unconformity is appreciably darker than that of the rest of the underlying beds in the set. In the 100 feet of sediments above the un-

Sections 11, 14, and 23, T. 14 N., R. 1 E.  
Sandoval County, New Mexico  
by Ted Galusha  
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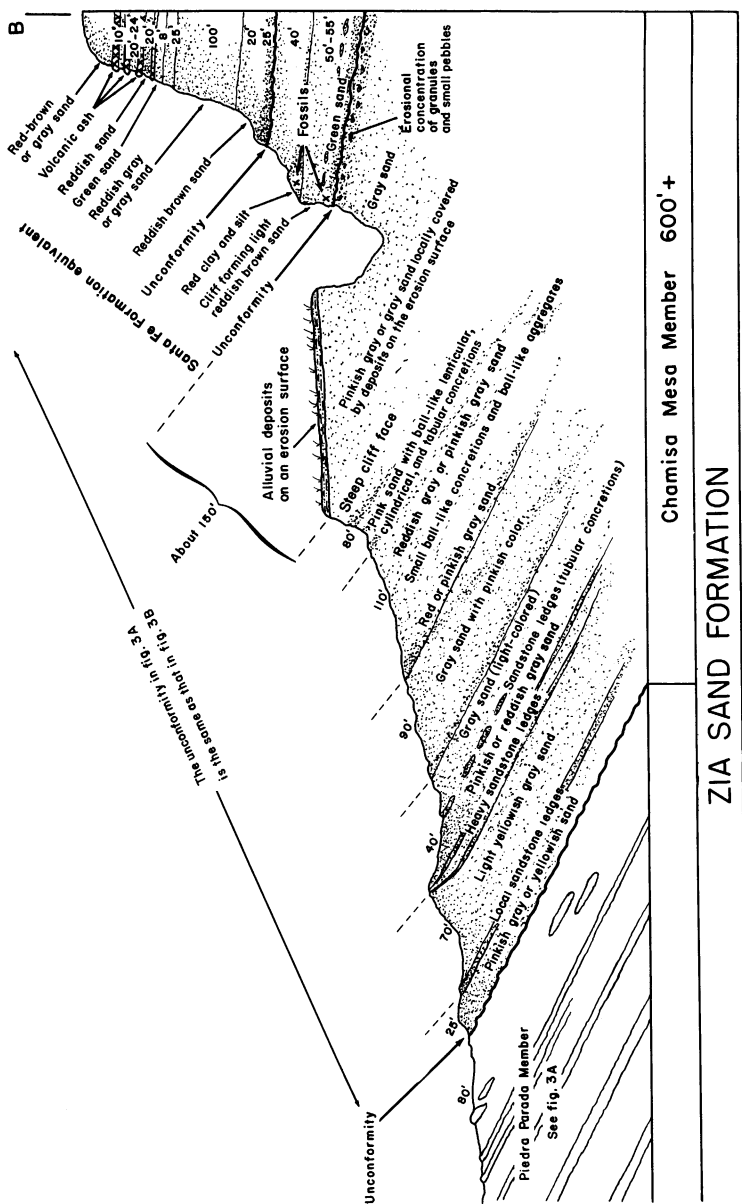


FIG. 3B. Continuation of type section of Zia Sand Formation. Unconformity in A is same as that in B, as indicated by arrows. Part of the Chamisa Mesa Member is shown in this section. A major angular unconformity is shown at the base of the Santa Fe Formation. Scale: Combined sections in A and B equal about 2½ miles. Dip of all beds arbitrarily exaggerated from 5 degrees to approximately 45 degrees.

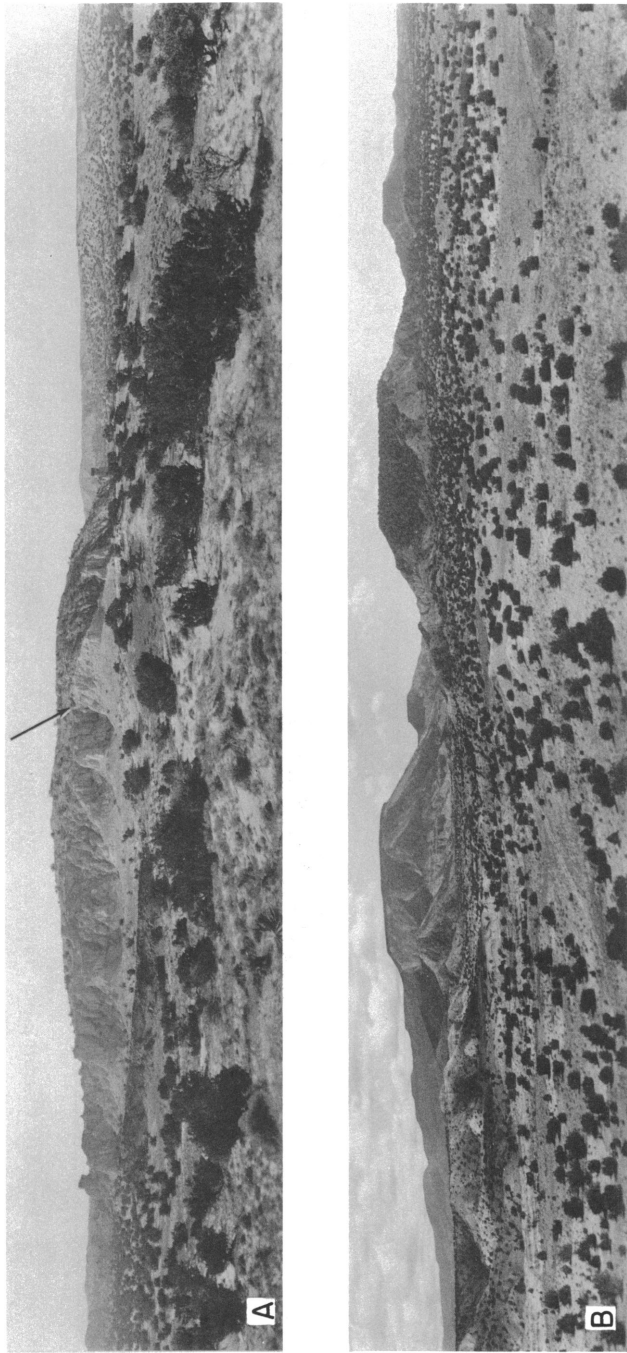


FIG. 4. A. Panoramic view (looking southeast) of the lower part of the type locality of the Zia Sand Formation. This is also the type section of the Piedra Parada Member of the Zia Sand. Most of the beds shown are near the center of sect. 11, T. 14 N., R. 1 E., of the New Mexico Principal Meridian in Sandoval County, New Mexico. The Standing Rock Quarry is on the crest of the ridge near the center of the picture as indicated by the arrow. The cliffs are Zia Sand; the slopes in the lower center and in the foreground are Galisteo Formation. B. Panoramic view (looking east) of a part of the Arroyo Pueblo drainage system. The type section of the Chamisa Mesa Member crops out between Blick Hill, the flat-topped hill at right center, and Chamisa Mesa, the high mesa on the skyline at left center.



conformity the beds have a distinctive light yellowish gray or pinkish gray color. It is possible that this unconformity may mark approximately the upper limit of the beds that produced a fauna equivalent to that of the Harrison Formation of the Arikaree Group of the Great Plains. The provincial age classification of the lower part of the Zia Sand is, therefore, late Arikareean of early Miocene time.

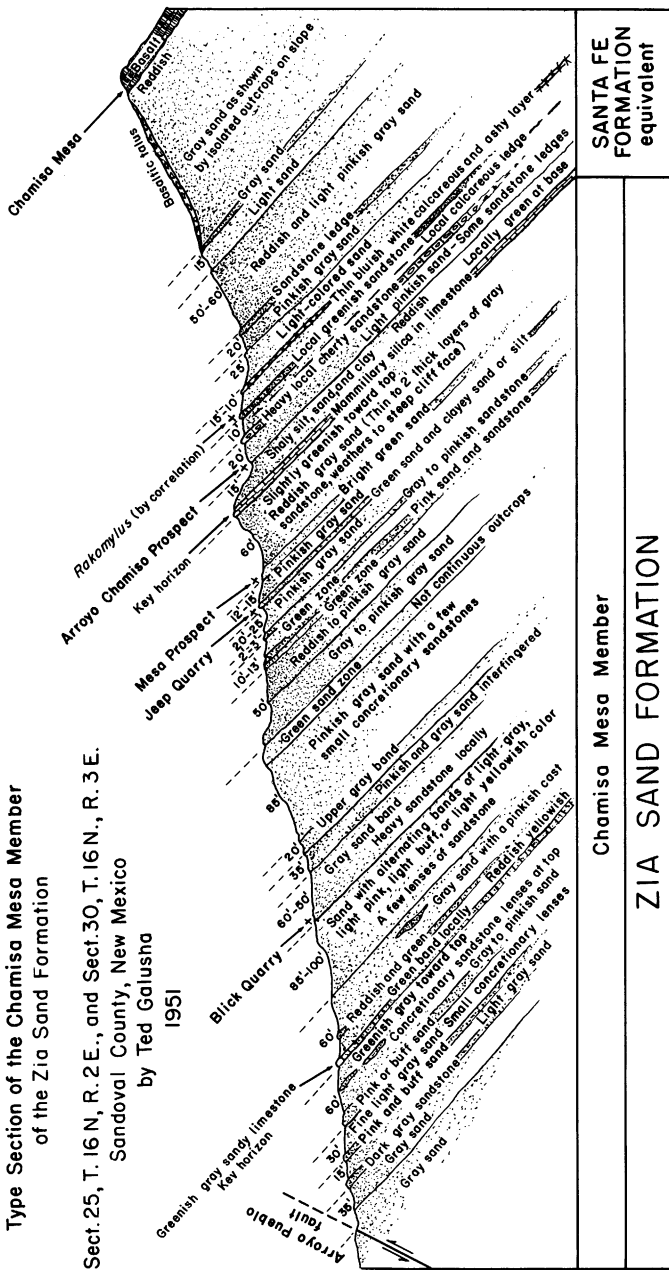
A new member name is hereby proposed for the approximately 400 feet of the lower part of the type section of the Zia Sand lying below the obscure unconformity. This portion of the type section of the Zia Sand Formation is also designated as the type section of the Piedra Parada Member. The name is derived from the Canyada Piedra Parada which drains the type locality.

A new member name is also proposed for the upper part of the Zia Sand, which is best exposed along the Arroyo Pueblo in the N.  $\frac{1}{2}$  of sect. 25, T. 16 N., R. 2 E., and sect. 30, T. 16 N., R. 3 E. This member is here named the Chamisa Mesa Member for the prominent, basalt-capped Chamisa Mesa on the flanks of which a part of the beds of the member crops out. A type section of the Chamisa Mesa Member is shown in figure 5. The base of the member is not exposed in the Arroyo Pueblo but is cut off and buried on the west by the Arroyo Pueblo fault. However, about 300 feet of sediments are exposed below the Blick Quarry. The Jeep Quarry occurs about 275 feet to 300 feet stratigraphically above the Blick Quarry. The limestone ledge that crops out stratigraphically 75 feet above the Jeep Quarry horizon and contains distinctive mammillary inclusions of silica is here considered the top of the member. The beds overlying the Chamisa Mesa Member are correlated as part of the Santa Fe Formation.

The presence of four good fossil quarries in the type locality of the Chamisa Mesa Member, from each of which extensive collections have been made, will provide excellent biostratigraphic control for supplementary studies of the member. Several new genera and species have been obtained from these quarries, including a new, advanced stenomyline camel. Examples of previously described genera that have been collected from these quarries include *Menoceras* Barbour, *Protolabis* Cope, *Homocamelus* Leidy, *Subparacosoryx* Frick, *Promartes* Riggs, *Tomarctus* Cope, and *Cynarctoides* McGrew. These genera, if not precisely characteristic of Hemingfordian age, are, at least, compatible with the concept. The Chamisa Mesa Member was deposited during Hemingfordian time; therefore, the Zia Sand Formation covers a long time span extending from late Arikareean (Harrison Formation equivalent) to late Hemingfordian (Sheep Creek equivalent).

Not all of the uppermost beds of the Zia Sand Formation occur in

Sect. 25, T. 16 N., R. 2 E., and Sect. 30, T. 16 N., R. 3 E.  
Sandoval County, New Mexico  
by Ted Galusha  
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the type area in the Canyada Piedra Parada owing to the removal of part of the beds during the erosion interval represented by the strong unconformity at the contact of early Pliocene sediments of the Santa Fe on the Zia Sand. The missing beds are believed to be represented in the Arroyo Pueblo locality and, for that reason, the beds there were selected as the type section of the Chamisa Mesa Member.

Beds that crop out along the Ceja del Rio Puerco in Canyada Navajo, Canyada Pilares, Canyada Moquino, and Canyada Benevides are here correlated as a part of the Chamisa Mesa Member of the Zia Sand on lithologic similarity and homotaxial position. These beds were described by Bryan and McCann (1937) as the Lower Gray Member of their three-fold division of the Santa Fe Formation. Lithic and faunal evidence is entirely lacking to justify correlating their Lower Gray Member with beds of the Santa Fe Formation.

B. Coleman Renick (1931) described the beds here named the Zia Sand Formation and cited a locality in the northern part of T. 14 N., R. 1 E., as a point where the contact of the Santa Fe Formation with beds of the Wasatch Formation was exposed. The Santa Fe beds cited by Renick are those designated here as part of the type locality of the Piedra Parada Member of the Zia Sand Formation; the beds thought by Renick to be Wasatch are here mapped as part of the Galisteo Formation.

Many of the fossils collected from the Zia Sand beds in the Ceja del Rio Puerco locality show that they are equivalent to those obtained from the uppermost beds as exposed in Arroyo Pueblo in the Jemez Creek area.

In the type locality the Zia Sand is unconformably overlain by about 500 feet of deposits of the Santa Fe Formation. This is the Middle Red of Bryan and McCann (1937) for which they cite sufficient rock-stratigraphic and biostratigraphic evidence. The contact between the two formations is shown in figure 2, and the details of the cross section, in figure 3. The Zia Sand, immediately underlying the contact with the Santa Fe, is a coarse-textured, dark gray sand from which the smaller particles have been removed by deflation, leaving a concentration of granules and small pebbles. A very large collection of fossil specimens has been obtained from the Santa Fe beds in the area; a particularly good concentration of specimens was collected immediately above the contact with the underlying Zia Sand. These forms appear to be approximately equivalent to those from the Valentine Formation of Nebraska.

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