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TRIASSIC STRATIGRAPHY AROUND THE SANDIA UPLIFT, CENTRAL NEW MEXICO

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Abstract—Triassic strata crop out around the Sandia uplift in the Hagan basin, Placitas and Cedar Crest areas. A uniform Triassic section of nonmarine red siliciclastics as much as 480 m thick is exposed across all three areas. The base of the Triassic section is the Middle Triassic (Anisian) Anton Chico Member of the Moenkopi Formation, which disconformably overlies Permian limestones of the San Andres Formation. Moenkopi strata are as much as 20 m thick and mostly grayish red/pale-red litharenitic sandstones and siltstones. They are disconformably overlain by the Agua Zarca Formation of the Chinle Group, as much as 108 m of mostly yellowish gray sublitharenitic sandstone and extraformational conglomerate with clasts of quartzite and Paleozoic limestone. Overlying gray and purple mudstone dominated strata, as much as 92 m thick, may belong to the Salitral Formation. The uppermost Triassic strata exposed around the Sandia uplift are as much as 260 m of mostly reddish brown bentonitic mudstone assigned to the Petrified Forest Formation. A prominent, bench-forming sandstone/conglomerate unit as much as 37 m thick at the top of the Petrified Forest Formation is the Correo Member. It is disconformably overlain by the Middle Jurassic Entrada Sandstone. Few paleontological data are available from Triassic rocks around the Sandia uplift, but they can be readily correlated to nearby Triassic strata on the southern Colorado Plateau and on the southern High Plains, principally by lithostratigraphy.

INTRODUCTION

Triassic strata exposed around the Sandia uplift in Bernalillo and Sandoval counties, New Mexico, crop out in three areas (Fig. 1). The largest Triassic outcrop belt is in the Hagan basin, an eastward tilted half graben that forms an embayment on the northeastern side of the Albuquerque basin. Immediately to the south, Triassic strata crop out around Placitas in a structurally complex transition and accommodation zone between two en-echelon, rift-bounding faults. To the southeast, on the eastern dip slope of the Sandia uplift, Triassic strata are exposed around Cedar Crest.

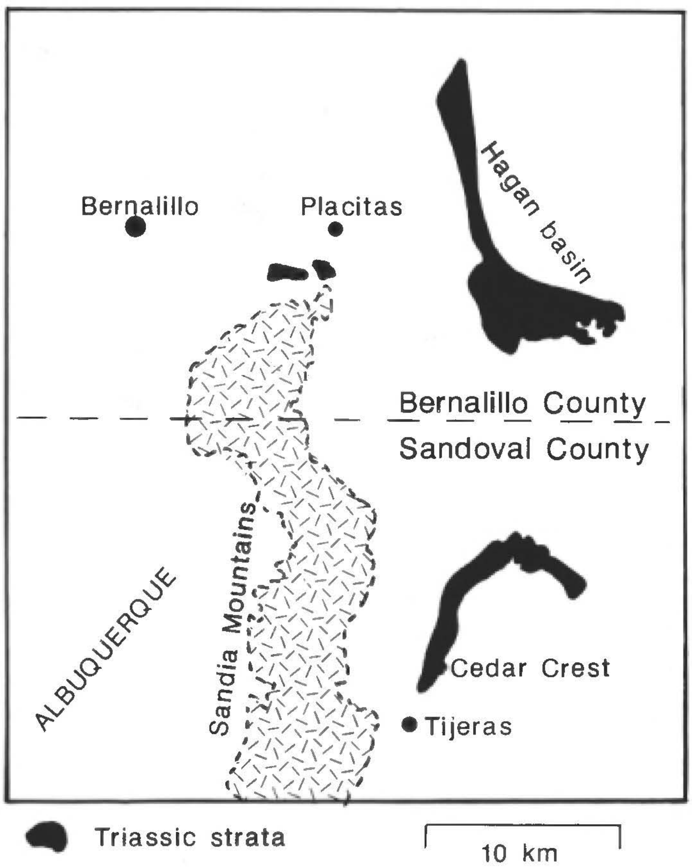

FIGURE 1. Location of Triassic exposures around the Sandia uplift (after Dane and Bachman, 1965).

Our purpose here is to review the stratigraphy of these Triassic outcrops to demonstrate that they present a nearly uniform Triassic section around the Sandia uplift. We also correlate these Triassic strata with those elsewhere in New Mexico. In this article, NMMNH refers to the New Mexico Museum of Natural History and Science, Albuquerque.

PREVIOUS STUDIES

Very little has been published on the Triassic strata surrounding the Sandia uplift. However, extensive data have been presented in University of New Mexico master's theses completed by Harrison (1949), Reynolds (1954), Picha (1982) and Menne (1989) (Fig. 2). Principal published works are Stearns (1953), Smith (1961), Kelley and Northrop (1975) and Lucas (1991) (Fig. 2).

Harrison (1949, p. 70-80) assigned Triassic strata in the Hagan basin to the Dockum Group with a total thickness of 2101 feet. Although he attempted no further subdivision of the Triassic section, Harrison (1949, p. 78) identified a "bottom 330 feet sandstone unit" overlain by red-bed mudstones.

Reynolds (1954, p. 22-24) identified this sandstone-dominated interval as the Santa Rosa Sandstone overlain by red-bed mudstones of the Chinle Formation. He included both the Santa Rosa and Chinle in the Dockum Group, and reported a Santa Rosa thickness of 335 ft and a Chinle thickness (p. 24) of 1790 ft.

Stearns (1953, p. 465, fig. 2) merely assigned Triassic strata in the Hagan basin and Placitas area to the Dockum Group. He described these strata as 800± ft of "red and variegated sandstone and shale."

Smith (1961, table 1) assigned Triassic strata around the Sandia uplift to the Dockum Group, divided into a basal Santa Rosa Sandstone overlain by an "upper member." He described (p. 123) Harrison's (1949) report of a total Triassic thickness in the Hagan basin of 2100 feet as "excessive."

Kelley and Northrop (1975, p. 52-53, fig. 10, map 1) divided the Triassic section around the Sandia uplift into the Santa Rosa Sandstone overlain by the Chinle Formation and included both units in the Dockum Group. They estimated the thickness of the sandstone-dominated Santa Rosa Sandstone as about 100-400 ft, and the red mudstone dominated Chinle Formation as about 1300-1400 ft. Kelley (1977) repeated these observations (also see Kelley, 1963). Kelley and Northrop (1975, p. 52) also identified as Permian "Bernal Formation" as much as 75 ft of "tan-brown" sandstone between their Santa Rosa Sandstone and the underlying Bonney Canyon Member of the San Andres Formation.

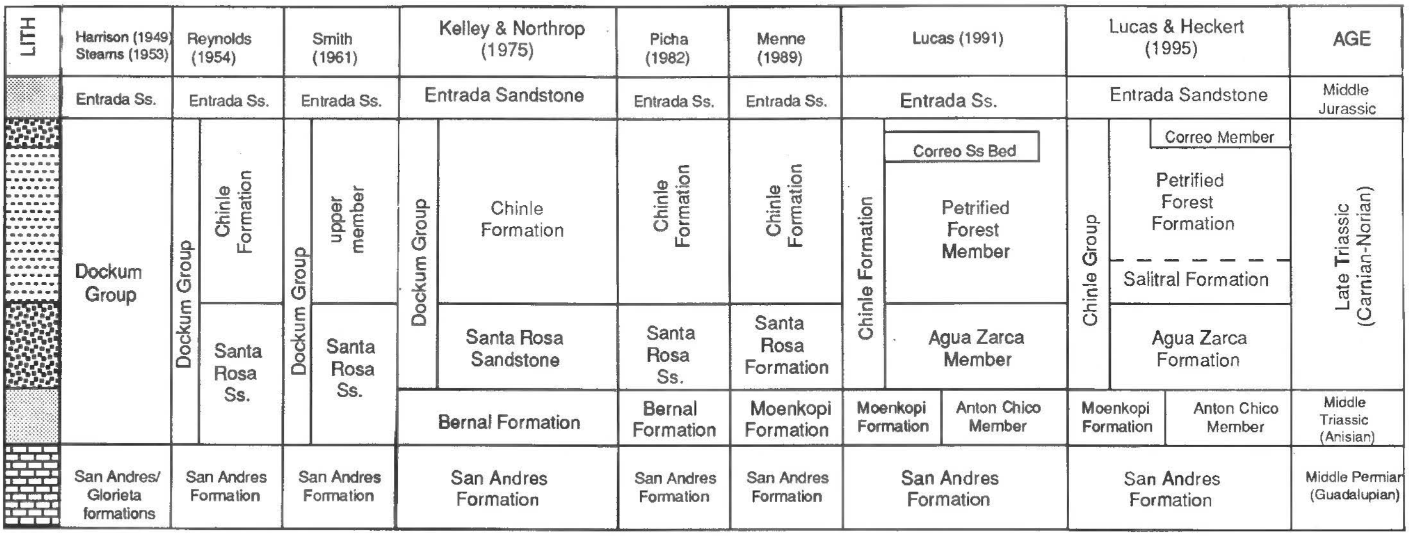

FIGURE 2. Comparison of stratigraphic nomenclature applied by previous workers to Triassic strata around the Sandia uplift with that advocated in this paper.

In the Hagan basin, Picha (1982, p. 41-48) identified the same Triassic stratigraphic units as Kelley and Northrop (1975): 30 m of Bernal Formation, overlain by as much as 80 m of Santa Rosa Sandstone capped by the Chinle Formation, as much as 484.5 m of mostly red-bed mudstones and thin sandstones and conglomerates. Picha (1982, p. 47), however, did identify a 12.2-m-thick sandstone and conglomerate interval near the top of his Chinle Formation as a "laterally-persistent Correo-equivalent."

In the Placitas area, Menne (1989, p. 20-24) divided the Triassic section into Moenkopi Formation, as much as 13.5 m of red-bed micaceous sandstone and mudstone; Santa Rosa Formation, as much as 67.5 m of white, gray, and tan sandstone and conglomerate; and Chinle Formation, with a partial thickness of 169 m of mostly red-bed mudstones.

The nomenclature we advocate for Triassic strata around the Sandia uplift follows Lucas and Hayden (1991) and Lucas (1991, 1993). Strata previously termed Bernal Formation of Permian age are, lithologically and biostratigraphically, assignable to the Anton Chico Member of the Moenkopi Formation (Lucas and Hayden, 1991). Overlying Triassic strata belong to the Chinle Group of Lucas (1993). The basal sandstone- and conglomerate-dominated strata of the Chinle Group are the Agua Zarca Formation of Wood and Northrop (1946). We reject previous use of the term Santa Rosa Formation (or Sandstone) for these strata because the tripartite division of the Santa Rosa Formation through east-central New Mexico due to its medial, mudstone-dominated Los Esteros Member (Lucas and Hunt, 1987) cannot be established around the Sandia uplift; no medial mudstone member is present. Overlying red mudstone-dominated strata of the Chinle Group belong to the Petrified Forest Formation as used by Lucas and Hunt (1992) and Lucas (1993). In the Hagan basin, however, a basal unit of gray, blue and olive mudstones may be an eastward extension of the Salitral Formation of the Chama basin and Nacimiento uplift (Lucas, 1991, 1993; Lucas and Hunt, 1992). The uppermost, sandstone- and conglomerate-dominated interval of the Petrified Forest Formation is identified as the Correo Member (Lucas et al., 1987, 1988; Lucas, 1991, 1993; Lucas and Heckert, 1994). The following text describes these units in detail and correlates them to nearby Triassic sections.

HAGAN BASIN

Around the Sandia uplift, Triassic strata are best exposed in the Hagan basin and were well mapped there most recently by Kelley and Northrop (1975, map 1) and Picha (1982, Fig. 1). Lucas (1991) described these strata in some detail and illustrated selected outcrops and fossils. We present here the data upon which Lucas (1991) based his description — five measured sections (Appendix 1, sections A-E) — and present a more detailed description.

The basal unit of the Triassic section in the Hagan basin is the Anton Chico Member of the Moenkopi Formation. Our section A, at which the Moenkopi Formation is 20 m thick, is representative (Fig. 3). Here, the Moenkopi disconformably overlies limestone of the Permian (Guadalupian) San Andres Formation and is disconformably overlain by conglomerate of the Agua Zarca Formation of the Chinle Group. Most of the Moenkopi Formation is pale red and very pale orange litharenitic sandstone that is trough crossbedded and ripple laminated. A subordinate rock-type is pale red siltstone.

The base of the overlying Agua Zarca Formation is typically a clast-supported, trough-crossbedded conglomerate. Clasts are extraformational quartzite, Paleozoic limestone and Moenkopi lithics. Fossil logs are com-

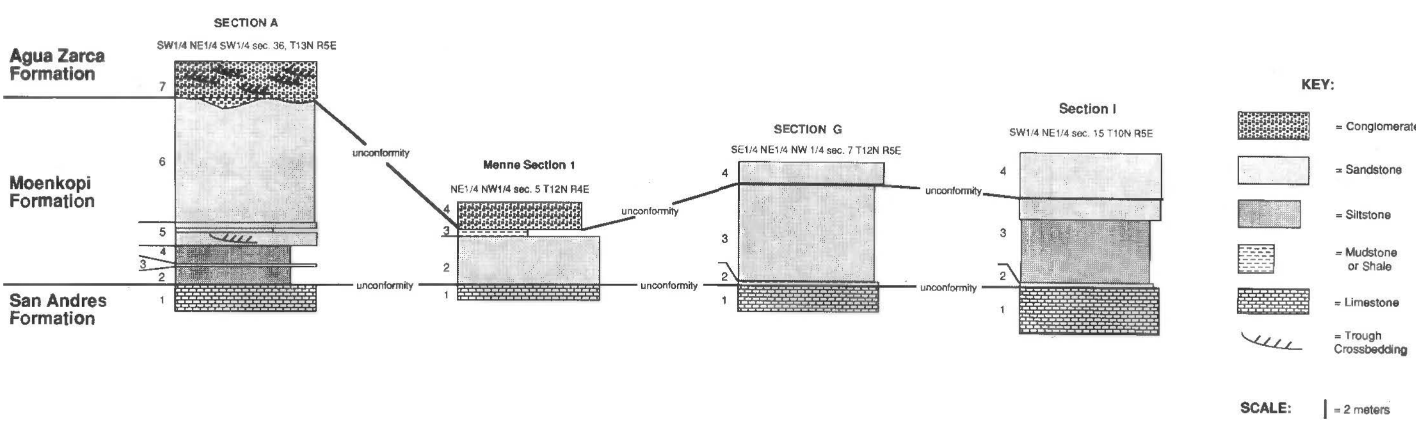

FIGURE 3. Stratigraphic sections of the Moenkopi Formation around the Sandia uplift. See Appendix for lithologic descriptions and locations of sections.

mon locally. Overlying Agua Zarca strata are mostly gray and yellowish gray trough-crossbedded, laminated, and ripple-laminated sublitharenitic sandstones. They typically form a prominent hogback. We measured Agua Zarca Formation thicknesses in the Hagan basin of 108.4 m (section B) and 87.1 m (section C) (Fig. 4).

The remainder of the Chinle Group in the Hagan basin is a thick, red mudstone-dominated unit that forms a long, N-S strike valley between the San Andres-Agua Zarca hogback to the west and the Jurassic Entrada hogbacks along Cañon Tejon to the east (Kelley and Northrop, 1975, map 1; Picha, 1982, fig. 1). In our section B (Fig. 4), the lower 91.6 m of this mudstone-dominated interval (units 11-21) are mostly gray and purple bentonitic mudstones and intraformational conglomerates that resemble, in stratigraphic position and lithology, the Salitral Formation of the Chama basin-Nacimiento uplift to the west. Lucas, (1991, p. 49) also noted this similarity, and we tentatively assign these strata in the Hagan basin to the Salitral Formation, even though the Poleo Formation, which overlies the Salitral Formation in the Chama basin-Nacimiento uplift, is absent in the Hagan basin.

Chinle strata above the Salitral Formation in the Hagan basin are 260.7 m (our section B: Fig. 4) of mostly grayish red and reddish brown bentonitic mudstone with relatively thin beds of litharenitic sandstone and intraformational (calcrete-clast) conglomerate. We assign these strata to the Petrified Forest Formation, as that unit was redefined by Lucas (1991, 1993) and Lucas and Hunt (1992).

The uppermost strata of the Petrified Forest Formation in the Hagan basin are a prominent ledge of crossbedded litharenite and mostly intraformational (some extraformational quartzite clasts are present) conglomerate. Following Picha (1982), Lucas et al. (1987, 1988) and Lucas (1991, 1993) we correlate this unit to the Correo Member of the Petrified Forest Formation in the Lucero uplift to the west (see Lucas and Heckert, 1994). We measured thicknesses of the Correo Member in the Hagan basin of 37.3 m (section B), 21.8 m (section D) and 5.4 m (section E) (Fig. 4). These thickness variations probably reflect differential erosion associated with the J-2 unconformity surface (Pipiringos and O'Sullivan, 1978) between the Correo and the overlying medial silty member of the Middle Jurassic Entrada Sandstone. Indeed, in the Hagan basin, the Entrada appears to bevel off the Correo completely at Puertecito in the SE¼SW¼SW¼ sec. 10, T12N, R6E. Throughout the Hagan basin, the medial silty member of the Entrada rests disconformably on the Correo Member of the Petrified Forest Formation or on a thin (<5 m) interval of red mudstone of the Petrified Forest Formation just above the Correo Member.

PLACITAS AREA

Triassic strata crop out along the northwestern edge of the Sandia uplift southwest of the village of Placitas in the NE corner of T12N, R4E and the NW corner of T12N, R5E. Kelley and Northrop (1975, map 1) and Menne (1989, Fig. 1-2) mapped the distribution of the structurally complex Triassic outcrops in this area. Menne (1989, p. 130-134) also described three stratigraphic sections of Triassic rocks in the Placitas area, and our sections and observations (Appendix 1, sections F-H) are in close agreement with hers.

The base of the Triassic section in the Placitas area is the Anton Chico Member of the Moenkopi Formation which disconformably overlies limestones of the Permian (Guadalupian) San Andres Formation. The Moenkopi Formation is grayish red and reddish brown micaceous litharenite sandstone and mudstone as much as 13.5 m thick. Its best exposures are at our section G (Fig. 3), near the head of the dirt road in the SE¼ NE¼ NW¼ sec. 7 (unsurveyed), T12N, R5E and just northwest of Tunnel Spring in the NW¼ SE¼ SW¼ sec. 5, T12N, R5E.

The Agua Zarca Formation of the Chinle Group disconformably overlies the Moenkopi Formation in the Placitas area. Menne (1989) estimated its total thickness as about 67 m. It is mostly grayish yellow to greenish yellow quartzarenite sandstone that is not very well exposed (Fig. 4).

Overlying red mudstones of the Chinle Group are at least 169 m thick but their base and lower one third to one half (?) are nowhere well exposed in the Placitas area (Fig. 4). The best exposures of these red beds,

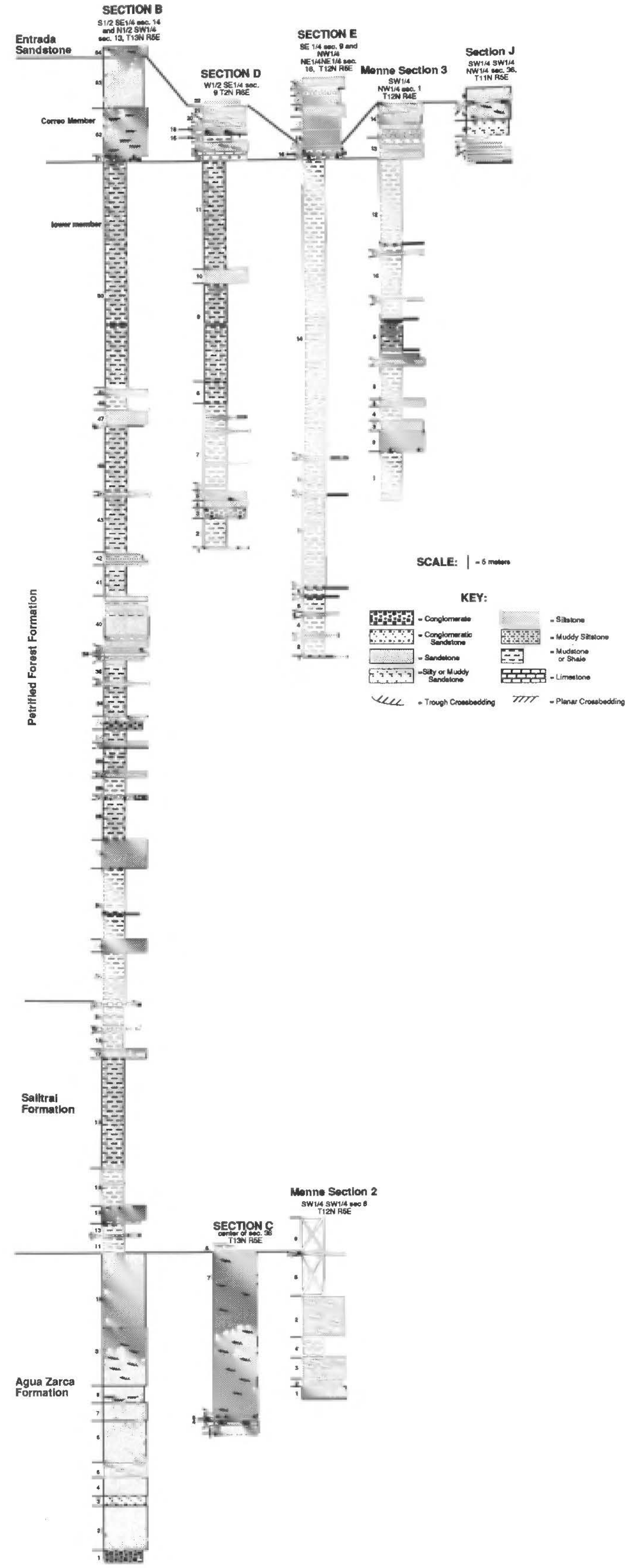

FIGURE 4. Stratigraphic sections of the Chinle Group around the Sandia uplift. See Appendix for lithologic descriptions and locations of sections.

which we correlate to similar Petrified Forest Formation strata in the Hagan basin immediately to the north, are in the SE¼ NE¼ sec. 1, T12N, R4E, just south of NM highway 44. Here, the upper portion of the Petrified Forest Formation is dominated by reddish brown bentonitic mudstones with thin ledges of litharenitic sandstone and intraformational conglomerate. The uppermost 15-20 m of the Petrified Forest Formation forms a prominent ledge of conglomerate and sandstone we identify as the Correo Member. Menne (1989, p. 132) showed two ledges of conglomerate/sandstone separated by 9 m of mudstone at the top of the Chinle section in this area. However, she missed a fault repeat; the lower of her two ledges is a gravity slide block equivalent to the upper ledge. A fault that strikes NW separates the two blocks in the SE¼ NW¼ sec. 1 T12N, R4E. The Correo Member is also well exposed about 0.9 km to the SE in the SW¼ NE¼ SW¼ sec. 6, T12N, R5E (our section F) where it yields fragmentary Late Triassic vertebrate fossils (see below). The Middle Jurassic Entrada Sandstone disconformably overlies the Correo Member in the Placitas area.

CEDAR CREST

Triassic strata are exposed in two outcrop belts in the Cedar Crest area on the southeastern flank of the Sandia uplift: from northwest of Tijeras to beyond Cañoncito in T10-11N, R5E on the dip slope of the Sandia Mountains; and east of San Antonito in secs. 20-21, 28-29, and 33, T11N, R6E on the northeastern flank of the Tijeras syncline. Outcrop quality in these two belts is poor due to soil and vegetation cover. Because of this, we did not measure a complete section of the Triassic strata. Instead, we measured three short sections and made stratigraphic observations at other localities (Appendix 1). These indicate the Triassic section in the Cedar Crest area is very similar to that in the Hagan basin with one important exception - the Correo Member of the Petrified Forest Formation is absent in the Cedar Crest area.

The basal unit of the Triassic section in the Cedar Crest area is the Anton Chico Member of the Moenkopi Formation. It is well exposed at our section I (SW¼ NE¼ sec. 15, T10N, R5E) where 11.2 m of red Moenkopi sandstone and siltstone disconformably overlie the San Andres Formation and are disconformably overlain by the Agua Zarca Formation (Fig. 3). Moenkopi strata here are gray to pale red; sandstones are ripple-laminated litharenites. To the north of the Hobbies section and throughout the Cedar Crest area, Moenkopi strata are very poorly exposed, usually underlying a covered slope between San Andres and Agua Zarca hogbacks.

The base of the Chinle Group in the Cedar Crest area is the Agua Zarca Formation. We were not able to measure a complete thickness of the Agua Zarca Formation here, but estimate its thickness from Kelley's (in Kelley and Northrop, 1975, map 1) mapping as 100 m. Kelley mapped this unit as Santa Rosa Formation, but at Cedar Crest, as in the Hagan basin and Placitas areas, it lacks a medial mudstone member, so we refer to it as Agua Zarca Formation. Here it is gray and grayish yellow, trough crossbedded sandstones-quartzarenites to sublitharenites (Appendix 1, section J).

Overlying Chinle Group strata belong to the Petrified Forest Formation. These are mudstone-dominated red beds with thin, often lenticular, beds of sandstone and intraformational conglomerate. The Petrified Forest Formation is so poorly exposed in the Cedar Crest area that we did not measure a complete section. We estimate its thickness from Kelley's mapping as about 300 m.

The top of the Petrified Forest Formation in the Cedar Crest area does not appear to be in the Correo Member. In our section J (see Appendix) relatively fine-grained sandstones, siltstones, and mudstones cap the Petrified Forest Formation under the Entrada Sandstone. The Petrified Forest-Entrada contact here, however, may be a low angle fault, obscuring the exact stratigraphic relationships. Nevertheless, no hogback is formed in the Cedar Crest area by Correo sandstone/conglomerate, so the Correo Member appears to be absent in this area.

STRATIGRAPHIC SUMMARY

We summarize briefly the Triassic section exposed around the Sandia uplift in the Hagan basin, Placitas and Cedar Crest areas. These strata belong to the Moenkopi Formation and the Agua Zarca, Salitral? and Petrified Forest formations of the Chinle Group.

Moenkopi Formation

The oldest Triassic strata exposed around the Sandia uplift belong to the Anton Chico Member of the Moenkopi Formation, as much as 20 m of mostly grayish red and pale red litharenitic sandstones and siltstones. The Moenkopi disconformably overlies the San Andres Formation and is disconformably overlain by the Agua Zarca Formation of the Chinle Group.

Some previous workers (Kelley and Northrop, 1975; Picha, 1982) assigned Moenkopi strata around the Sandia uplift to the Permian "Bernal" (=Artesia) Formation. However, these fluvial, texturally immature red beds are dissimilar to Artesia ("Bernal") strata to the east and identical to Moenkopi strata east and west of the Sandia uplift (Lucas and Hayden, 1991).

Chinle Group

Agua Zarca Formation

Strata that disconformably overlie the Moenkopi Formation around the Sandia uplift are a sandstone-dominated unit as much as 108 m thick that we assign to the Agua Zarca Formation. Previous workers identified this unit as the Santa Rosa Sandstone (or Formation), but it is more similar to the Agua Zarca, particularly in the absence of a medial mudstone member, which is characteristic of the Santa Rosa to the east. Agua Zarca conglomerates contain significant amounts of extrabasinal clasts of quartzite and Paleozoic limestone. Sandstones are mostly sublitharenites and quartzarenites; dominant colors are gray and yellowish gray. Petrified logs are common at some Agua Zarca outcrops. The unit tends to form hogbacks.

Salitral Formation

About 92 m of mostly gray and purple bentonitic mudstones and intraformational conglomerates overlie the Agua Zarca Formation in the Hagan basin. These strata are tentatively assigned to the Salitral Formation, which they lithologically resemble. Because of poor exposures, their presence in the Placitas and Cedar Crest areas cannot be confirmed.

Petrified Forest Formation

A thick (260 m) section of mostly reddish brown bentonitic mudstones caps the Triassic section around the Sandia uplift. We assign these strata to the Petrified Forest Formation. A prominent ledge of conglomerate and sandstone, as much as 37 m thick, is at the top of the Petrified Forest Formation in the Hagan basin and Placitas area and is assigned to the Correo Member. The Middle Jurassic Entrada Sandstone disconformably overlies the Petrified Forest Formation around the Sandia uplift.

PALEONTOLOGY

Very few fossils of biostratigraphic significance are known from the Triassic strata around the Sandia uplift. Known occurrences are:

1. Indeterminate bone fragments and coprolites are present in the Moenkopi Formation in the Hagan basin in the NW¼ NW¼ NW¼ sec. 25 (unsurveyed), T13N, R5E.

2. Fossil logs are common locally in the Agua Zarca Formation, and Lucas (1991, fig. 4C) illustrated one of these logs in the NE¼ SW¼ sec. 36, T13N, R5E. These logs are of no biochronological significance except that they are common in basal sandstone/conglomerate complexes of the Chinle Group (Shinarump, Agua Zarca, Santa Rosa formations).

3. In the Department of Geology of the University of New Mexico, there is a specimen of *Otozamites powelli* from the "Santa Rosa Sandstone" in the Hagan basin, but no more precise locality data are available. *Otozamites powelli* is a common constituent of Ash's (1980) *Dinophyton* floral zone of late Carnian age.

4. Indeterminate reptilian bones (NMMNH 22433) and large metoposaurid bones (see Lucas, 1991, fig. 4D) are present in the Salitral Formation? in the Hagan basin at NMMNH locality 3029 at UTM 3906130N, 376140E, zone 13.

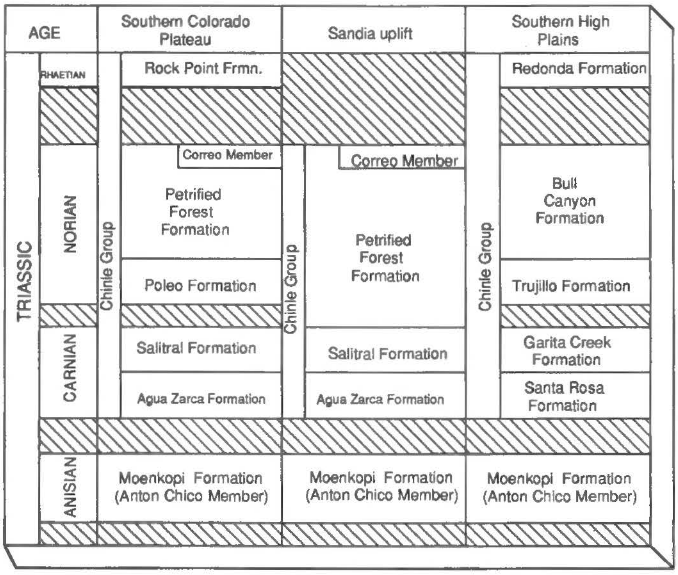

FIGURE 5. Correlation of Triassic stratigraphic units from the southern Colorado Plateau to the Sandia uplift and to the southern High Plains (after Lucas, 1991, 1993).

5. Poorly preserved unionid bivalves are present in the Petrified Forest Formation near Placitas at NMMNH locality 845 in the SE¼ SE¼ NW¼ SE¼ sec. 1, T12N, R4E.

6. The Correo Member of the Petrified Forest Formation produced vertebrate coprolites, unionids, phytosaurs, the amphibian *Apachesaurus* and possible *Typothorax* (Lucas, 1991, fig. 6) from NMMNH localities 250, 251, 252, and 3028 in the Hagan basin: 250- SW¼ sec. 5, T12N, R6E; 251- NE¼ NE¼ sec. 1, T12N R5E; 252- sec. 13, T13N, R5E; 3028- NW¼ SE¼ sec. 12, T12N, R6E. In the Placitas area, the Correo Member produced phytosaur (NMMNH P-22434) and large metoposaur (NMMNH P-22435) bones at NMMNH locality 3030 at UTM 3906600N, 367630E, zone 13.

The above listed fossils suggest that the Agua Zarca and Salitral? formations are of late Carnian age, whereas the Correo Member is Norian. They thus support the correlation of Triassic strata around the Sandia uplift with nearby Triassic strata advocated here (Fig. 5).

CORRELATION

Correlation of the Triassic section exposed around the Sandia uplift with Triassic strata exposed along the southern Colorado Plateau to the west and to the east along the southern High Plains (Fig. 5) has already been discussed in detail by Lucas (1991, 1993) and Hunt and Lucas (1993). This correlation is primarily based on lithostratigraphy, supplemented by and consistent with the limited Triassic paleontology available from the Sandia uplift.

ACKNOWLEDGMENTS

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APPENDIX: LITHOLOGICAL DESCRIPTIONS

Section A

Measured 21 May 1988 in the Hagan basin near the ghost town of Tejon, SW1/4 NE1/4 SW1/4 sec. 36, T13N, R5E. Strata dip 34° to N88°E.

unit	lithology	thickness (m)
	Chinle Group:	
	Agua Zarca Formation:	
7	Clast-supported conglomerate; olive gray (5Y4/1) to dark greenish gray (5GY4/1); clasts are quartz, limestone and mudstone pebbles up to 10 mm in diameter; matrix is mostly mudstone; up to 2 m erosional relief at base; trough crossbedded; some petrified wood/logs; very calcareous.	not measured
	unconformity (Tr-3 unconformity of Pipringos and O'Sullivan, 1978)	
	Moenkopi Formation:	
	Anton Chico Member:	
6	Sandstone; very pale orange (10YR8/2); very fine- to medium-grained, subangular, poorly sorted litharenite; massive to ripple laminar; intermittent small lenticular channels 5-10 m long every 2 m on strike; very calcareous.	14.0

unit	lithology	thickness (m)
5	Sandstone; pale red (10R6/2) fresh, weathers to pale reddish brown (10R5/4); fine- to medium-grained, subrounded, poorly sorted sublitharenite; low angle crossbeds; minor mudstones; not calcareous.	2.4
4	Same color and lithology as unit 2.	1.5
3	Sandstone; pinkish gray (5YR8/1) fresh, weathers pale red (10R6/2); fine- to medium-grained, subrounded, well-sorted sublitharenite; low angle trough crossbeds; calcareous.	0.3
2	Siltstone and sandstone; siltstone is pale red (5R6/2); very weakly calcareous; sandstone is pale reddish brown (10R5/4); muddy lenses up to 5 mm long are grayish red (5R4/2); fine-grained, subangular, well-sorted litharenite; not calcareous.	1.8
	unconformity	
	San Andres Formation:	
1	Limestone; yellowish gray (5GY6/1) fresh; weathers to light olive gray (5Y6/1); micrite.	not measured

Section B

Section measured in the Hagan basin in the S½ SE¼ sec. 14 and N½ SW¼ sec. 13, T13N, R5E.

unit	lithology	thickness (m)
	Entrada Sandstone:	
	upper sandy member:	
54	Sandstone; yellowish gray (5Y7/2); fine-grained, well-rounded well-sorted litharenite; calcareous.	not measured
	unconformity (J-2 unconformity of Pipringos and O'Sullivan, 1978)	
	Chinle Group:	
	Petrified Forest Formation:	
	Correo Member:	
53	Sandstone; moderate reddish orange (10R6/6) to grayish orange pink (10R8/2); very fine-grained, rounded, well-sorted sublitharenite; much cover; calcareous.	18.1
52	Sandstone; grayish orange pink (5YR7/2), weathers pale reddish brown (10R5/4); medium-grained, subrounded, well-sorted litharenite; planar crossbeds with some conglomerate; lower 6 m is cliff-forming, upper 12 m mostly covered; calcareous.	18.0
51	Conglomerate and conglomeratic sandstone; medium dark gray (N4) to medium light gray (N6); conglomerate clasts are grayish red (5R/42) mudstone rip-ups up to 3 cm in diameter; matrix is fine- to very coarse-grained, subangular, poorly-sorted litharenite; trough crossbeds; cliff-forming; calcareous.	1.2
	lower member:	
50	Mudstone; same color and lithology as units 43 and 22; mostly covered; thin conglomerate lenses in places.	
49	Sandstone; same color and lithology as unit 38.	2.8
48	Mudstone; same color and lithology as unit 43 and 22.	5.3
47	Sandstone; same color and lithology as unit 38.	4.7
46	Conglomerate; same color and lithology as unit 37.	0.3
45	Mudstone; same color and lithology as unit 43.	23.6
44	Sandstone; same color and lithology as unit 38.	1.6
43	Mudstone; same color and lithology as unit 22.	20.2
42	Sandstone and conglomerate; dip changes to 20º; same colors and lithologies as units 38, 39, and 40, but not the same sequence, some shale like unit 22.	4.7
41	Mudstone; same color and lithology as unit 22.	11.8
40	Sandstone; same color and lithology as unit 38; some conglomerate has same color and lithology as unit 37.	19.5
39	Conglomerate; same color and lithology as unit 37; lenticular.	1.6
38	Laminar red sandstone.	1.6
37	Conglomerate; same color and lithology as unit 27.	1.2
36	Mudstone; same color and lithology as unit 22.	7.8
35	Sandstone; pale reddish brown (10R5/4); fine- to medium grained, subangular, moderately well-sorted litharenite; laminar; some thin mudstone interbeds; calcareous.	1.6
34	Mudstone; same color and lithology as unit 22.	10.9
33	Conglomerate, fining upward to sandstone; medium gray (N5) and medium light gray (N6) to pale red (10R6/2); clasts are small (2-5 mm) intraformational rip-ups; sandstone is primarily pale red (10R6/2); fine-grained, subrounded, well-sorted litharenite; conglomerate is very calcareous; sandstone is calcareous.	5.3
32	Mudstone; same color and lithology as unit 22.	4.7
31	Silty sandstone; grayish red (5R4/2); fine- to medium-grained, subrounded, poorly sorted litharenite; weakly calcareous.	1.6
30	Mudstone; same color and lithology as unit 22.	9.0
29	Sandstone; same color and lithology as unit 25.	1.7
28	Mudstone; same color and lithology as unit 22.	6.2
27	Conglomerate; light greenish gray (5GY8/1) fresh; stained to moderate orange pink (10R7/4); clasts are intraformational mudstone rip-ups of typical Chinle colors and lithologies; clasts vary from 2-10 mm in diameter; matrix is very coarse-grained, angular, moderately well sorted litharenite; shoestring geometry; very calcareous.	1.7
26	Mudstone; same color and lithology as unit 22.	14.3
25	Sandstone interbedded with mudstones of unit 22 lithology; olive gray (5Y4/1) to light greenish gray (5GY8/1) fresh, weathers/stained to pale red (5R6/2); very fine-grained, subangular, well-sorted litharenite; platy; weakly calcareous.	10.5
24	Mudstone; same color and lithology as unit 22; 0.3-m-thick conglomerate 9 m above the base of this unit.	26.0
23	Sandstone; grayish red (5R4/2) and yellowish gray (5Y7/2); very fine- to medium-grained, subangular, poorly sorted sublitharenite; very weakly calcareous.	4.7
22	Mudstone; moderate reddish brown (10R4/6) with large mottles of grayish yellow green (5GY7/2); bentonitic; includes a 0.3-m-thick matrix-supported conglomerate of identical colors; unit contains large (5.5 cm long axis)barite chips from veins that are pinkish gray (5YR8/1) to light gray (N7); muds and conglomerate are calcareous.	18.6
	Salitral Formation:	
21	Conglomerate; same color and lithology as unit 19 but persistent.	1.2
20	Mudstone; same color and lithology as unit 16.	7.8
19	Clast-supported conglomerate; dark greenish gray (5GY4/1); clasts are intraformational mudstone balls and rip-ups 2-4 mm in diameter; matrix is primarily mudstone; very calcareous.	1.2
18	Mudstone; same color and lithology as unit 16.	6.2
	Above unit 17 dip changes to 21° at N30°E.	
17	Sandstone; medium light gray (N6) and light gray (N7); medium-grained, rounded, well-sorted; laminar; well-indurated; localized; not calcareous.	3.1
16	Mudstone; pale purple (5P6/2) and grayish red purple (5RP4/2); bentonitic; contains large (10 cm +) concretions that are variegated pale red (10R6/2), grayish red purple (5RP4), pale purple (5P6/2), light greenish gray (5GY8/1), and medium gray (N5); both are very calcareous.	41.0
	Cross fault so dip changes to 40°, lower 1.5 m of unit 16 equals unit 13.	
15	Silty mudstone; light greenish gray (5GY8/1) to pale grayish yellow (10Y8/2) and grayish yellow (5Y8/4); bentonitic; calcareous.	14.0
14	Sandstone and conglomerate; basal 0.9 m is conglomerate; dark greenish gray (5GY4/1) to yellowish gray (5Y8/1); clasts are primarily intraformational calcrete nodules with some mudstone rip-ups; extremely calcareous; well-indurated; upper 5.3 m is sandstone; light olive gray (5Y6/1) with flecks of pale yellowish orange (10YR8/6); fine-grained, subangular, moderately well-sorted litharenite; ripple laminated; some planar crossbeds at top of unit; caps low benches; calcareous.	6.2
13	Mudstone; grayish red (5R4/2) and grayish red purple (5RP4/2); some light-colored grayish pink (5R8/2) spots/ mottles; very calcareous.	4.7
12	Bone-bearing conglomerate; grayish red (10R4/2) to pale reddish brown (10R5/4); clasts are primarily intra-formational calcrete nodules with occasional mudstone rip-ups; clasts range from 2 to 35 mm in diameter; calcareous. Base must be minor fault.	0.3-0.6
11	Mudstone; variegated moderate reddish orange (10R6/6) and light greenish gray (5GY8/1); some small gypsum platelets; calcareous.	5.6
	Agua Zarca Formation:	
10	Sandstone; varied shades of gray, primarily light gray (N7); medium-grained, rounded, well-sorted sublitharenite; well-indurated due to quartz cement; laminar; some planes have parting lineations; others have ripple marks; calcareous.	27.2
	Fault; sandstones now dip 45° to N60°E	
	Below, beds are vertical	
9	Sandstone; yellowish gray fresh (5Y8/1), weathers to various shades, including dusky blue (5PB3/2); medium-to coarse-grained, subrounded, moderately well-sorted sublitharenite; very low angle crossbeds; largely covered; calcareous.	21.7

8	Sandstone, yellowish gray (5Y8/1) to shades of gray fresh, weathers to olive gray (5Y4/1) with black (N1) spots; medium-grained, subrounded, moderately well-sorted sublitharenite; well-indurated; laminar but in sets thicker than unit 7; lower half is very iron rich with planar crossbeds; not calcareous.	7.3
7	Sandstone; medium gray (N5) to very light gray (N8); fine- to medium grained, subrounded, moderately well-sorted sublitharenite; well-indurated; quartz cement; laminar; not calcareous.	6.4
6	Sandstone; light greenish gray (5GY8/1) fresh, weathers to medium gray (N5); medium-grained, subrounded, moderately well-sorted sublitharenite; well-indurated; massive; calcareous.	14.7
5	Sandstone; dark yellowish brown (10YR4/2); small troughs; much plant debris; clay balls at top.	5.4
4	Sandstone; light gray (N7) to very light gray (N8) fresh, weathers to olive gray (5Y4/1) and olive black (5Y2/1); some yellowish iron staining; fine- to medium-grained, subangular, moderately well-sorted sublitharenite; well-indurated; massive; calcareous.	6.4
3	Conglomeratic sandstone; medium light gray (N6) and medium gray (N5); clasts are dominantly chert; sandstone is coarse-grained, subrounded, moderately well-sorted litharenite; moderately well indurated; some fossil logs; crudely laminar; calcareous.	3.7
2	Sandstone; medium gray (N5) to medium dark gray (N6); medium-grained, subangular, well-sorted litharenite; friable; calcareous.	15.6
1	Conglomerate; pale greenish yellow (10Y8/2) to medium gray (N5) with grayish black (N2) clasts; clasts are Paleozoic limestone, heavily weathered, very angular, and as much as 20 mm in diameter; very calcareous.	not measured

Section C

Section measured in the Hagan basin in the SE¼ SW¼ NW¼ of sec. 36, T13N, R5E (unsurveyed).

unit	lithology	thickness(m)
	Chinle Group:	
	Agua Zarca Formation:	
7	Sandstone; pale greenish yellow (10Y8/2) to yellowish gray (5Y7/2); fine- to coarse-grained layers of angular, moderately well-sorted, quartzarenite; quartz cement; slightly calcareous; laminated and trough crossbedded.	81.0
6	Conglomerate and conglomeratic sandstone; light olive gray (5Y5/2) to yellowish gray (5Y7/2) to medium gray (N5); clasts are cherts, quartzite and mudstone rip-ups, many of which are weathered to voids; matrix is quartzose sandstone; calcareous.	0.9
5	Sandstone; moderate olive brown (5Y4/4) to dusky yellow (5Y6/4); fine-grained, subrounded, well-sorted sublitharenite; calcareous; laminated.	0.9
4	Sandstone and conglomeratic sandstone; olive gray (5Y3/2) to light olive gray (5Y5/2); coarse- to very coarse-grained, rounded, moderately well-sorted; well indurated; few conglomeratic clasts are 2-3 mm in diameter; very calcareous; trough crossbeds.	0.3
3	Conglomerate; yellowish gray (5Y7/2) to light greenish gray (5GY8/1); clasts are dominantly medium gray (N5) to black (N1) mudstone balls; matrix is coarse-grained, subangular, well-sorted quartzarenite; not calcareous; trough crossbeds.	0.3
2	Sandstone; moderate reddish brown (10R4/6); sublitharenite; fine- to medium-grained; laminated.	3.1
1	Conglomerate; moderate reddish brown (10R4/6); clasts are Moenkopi mudstone and siltstone; laminated.	0.6

Section D

Section measured in the Hagan basin in W½ SE¼ sec. 6 (unsurveyed), T2N, R6E.

unit	lithology	thickness (m)
	Entrada Sandstone:	
	medial silty member:	
22	Sandstone; moderate reddish orange (10R6/6); very fine- to fine-grained, subrounded, poorly sorted litharenite; calcareous.	1.5
	Chinle Group:	
	Petrified Forest Formation:	
	Correo Member:	
21	Sandstone; same color and lithology as unit 14.	6.4
20	Sandstone; pale reddish brown (10R5/4) to medium gray (N5); coarse-grained, subangular, moderately well-sorted litharenite; some rare clasts greater than 2.0 mm in diameter; trough crossbedded; calcareous.	0.6
19	Sandstone; same color and lithology as unit 14.	2.1
18	Conglomerate; same color and lithology as unit 16.	0.9
17	Sandstone; same color and lithology as unit 14.	1.8
16	Conglomerate; same color and lithology as unit 16.	0.6
15	Shale; light bluish gray (5B7/1); thin ripple marked sandstone on top, much covered.	2.4
14	Sandstone; grayish orange pink (10R8/2); medium- to coarse-grained, subangular, poorly sublitharenite; calcareous; some low angle crossbeds	3.4
13	Conglomerate and conglomeratic sandstone; light greenish gray (5GY8/1) fresh, weathers to dark greenish gray (5GY4/1); clasts are moderate reddish brown (10R4/6) mudstone rip-ups up to 18 mm in length; sandstone matrix is medium-grained, angular, moderately well-sorted litharenite; calcareous.	1.5
12	Sandstone and conglomerate; variegated grayish red (10R4/2), light olive gray (5Y5/2), and grayish yellow green (5GY7/2); rock is poorly sorted mixture of intraformational clasts, quartz sandstones, minor chert pebbles, and calcareous mudstone; thin to thickly bedded; cliff-former; very calcareous.	2.1
	lower member:	
11	Much covered interval, primarily moderate reddish brown (10R4/6) bentonitic mudstone with thin lenticular sandstone bodies.	40.5
10	Sandstone; pale reddish brown (10R5/4); very fine-grained, subrounded, well-sorted sublitharenite; not calcareous.	5.2
9	Bentonitic mudstone; clayey, much covered.	36.0
8	Sandstone; pale red purple (5RP6/2); fine-grained, rounded, well-sorted sublitharenite; calcareous.	2.4
7	Mudstone with interbeds/lenses of sandstone; mudstone is grayish red (5R4/2); bentonitic; calcareous; sandstones are pale reddish brown (10R5/4); very fine-grained, subrounded, moderately well-sorted; very weakly calcareous.	33.5
6	Slightly silty mudstone; medium gray (N5); bentonitic; calcareous.	1.5
5	Sandstone; pale red (10R6/2) fresh, stains to grayish red (10R4/2); medium-grained, subangular, moderately well-sorted litharenite; small scale crossbeds; calcareous.	3.7
4	Sandstone; pale reddish brown (10R5/4); fine-grained, subangular, moderately well-sorted; very thinly ripple laminated; calcareous.	2.4
3	Clast supported, bone-bearing conglomerate; pale reddish brown (10R5/4); clasts are primarily intraformational mud balls; very calcareous.	4.0
2	Mudstone; moderate reddish brown (10R4/6); bentonitic; not calcareous.	10.0
1	Sandstone; moderate orange pink (10R7/4) fresh, weathers to grayish red (10R4/2); fine-grained, subrounded, moderately well-sorted litharenite; thinly laminated; calcareous.	0.6

Section E

Section measured in the Hagan basin in the SE¼ sec. 9 and NW¼ NE¼ NE¼ NE¼ sec. 16, T12N, R6E.

unit	lithology	thickness (m)
	Entrada Sandstone (Middle Jurassic):	
	upper sandy member:	
25	Sandstone; yellowish gray (5Y7/2); fine-grained, well-rounded well-sorted litharenite; calcareous.	not measured
	medial silty member:	
24	Siltstone; yellowish gray (5Y7/2) to pale olive (10Y6/2); massive; not calcareous.	0.3
23	Very sandy siltstone and silty sandstone; pale olive (10Y6/2) to light olive gray (5Y5/2); sandstone is very fine-grained, subrounded, well-sorted; cliff-forming unit; not calcareous.	2.4
22	Siltstone; pale brown (5YR5/2) to olive gray (5Y4/1); some mudstone interbeds; calcareous.	3.3
21	Siltstone and very fine-grained sandstone; pale red (10R6/2); sandstone is very fine-grained, subrounded, well-sorted litharenite; some low angle crossbeds; massive; calcareous.	4.6

20	Sandstone; pale reddish brown (10R5/4); very fine- to medium-grained, subrounded, poorly-sorted litharenite; thinly bedded; very calcareous.	4.6
19	Very sandy siltstone and silty sandstone; pale reddish brown (10R5/4) to moderate reddish orange (10R6/6); sandstone is very fine-grained, subangular, moderately well-sorted litharenite; massive to crudely bedded; calcareous.	6.1
	Chinle Group:	
	Petrified Forest Formation:	
	Correo Member:	
18	Sandstone; pale reddish brown (10R5/4) to medium gray (N5); coarse-grained, subangular, moderately well-sorted litharenite; some rare clasts greater than 2.0 mm in diameter; trough crossbedded; calcareous.	0.9
17	Sandstone; grayish red (10R4/2); medium- to coarse-grained, subangular, moderately well-sorted litharenite; very calcareous.	1.8
16	Sandstone; pale red (5R6/2); fine- to medium-grained, subrounded, moderately well-sorted litharenite; laminated; weakly calcareous.	0.6
15	Conglomerate; variegated grayish red (10R4/2), light olive gray (5Y5/2), and grayish yellow green (5GY7/2); rock is poorly sorted mixture of intraformational clasts, quartz sandstone, minor chert pebbles, and calcareous mudstone; thin to thickly bedded; cliff-former; very calcareous.	2.1
	lower member:	
14	Much covered interval, primarily reddish brown bentonitic mudstone with thin lenticular sandstone bodies.	108.0
13	Sandstone; brownish gray (5YR4/1); fine-grained, subrounded; well-sorted litharenite; thinly bedded; calcareous.	0.9
12	Bentonitic mudstone; red and clayey in outcrop; much vegetation and cover.	12.2
11	Sandy siltstone; grayish red purple (5RP4/2); not calcareous.	0.6
10	Siltstone; dark reddish brown (10R3/4); not calcareous.	35.1
9	Silty sandstone; pale reddish brown (10R5/4); very fine-grained, subrounded, well-sorted except for some medium-grained lithics, litharenite; laminated; not calcareous.	0.6
8	Bentonitic mudstone; clayey, much covered.	2.4
7	Conglomerate; grayish red (5R4/2 and 10R4/2) to grayish red purple (5RP4/2); clast-supported with clasts being rounded intra-formational mudstone rip-ups; very calcareous.	0.6
6	Silty mudstone; grayish-red (10R4/2) to pale reddish brown (10R5/4); calcareous.	5.8
5	Siltstone; grayish red (10R4/2); slightly micaceous; laminated; not calcareous.	2.0
4	Mudstone; pale reddish brown (10R5/4); bentonitic; calcareous; slope-former.	6.1
3	Siltstone; pale reddish brown (10R5/4); ripple laminated; calcareous; some mudstone interbeds of same color.	1.2
2	Mudstone; grayish red (10R4/2) to pale reddish brown (10R5/4); bentonitic; weakly calcareous; much vegetated.	7.0
1	Sandstone; grayish red purple (5RP4/2) and grayish red (10R4/2); fine-grained, subangular to subrounded, well-sorted, slightly micaceous litharenite; laminated; not calcareous.	1.2

Section F

Sampled near Placitas in the SW¼ NE¼ SW¼ sec. 6 T12N R5E. Strata dip 30° to N15°E

unit	lithology
	Chinle Group:
	Petrified Forest Formation:
	Correo Member:
5	Sandstone; pale purple (5P6/2) to pale blue (5PB7/2) fresh, weathering to dark gray (N3), some iron staining to dark reddish brown (10R3/4); medium- to coarse-grained, subrounded, moderately poorly sorted litharenite; well-indurated; calcareous.
4	Sandstone; pale red (10R6/2) to grayish red (10R4/2); fine- to medium-grained, subrounded, moderately well-sorted litharenite; calcareous.
3	Sandstone and conglomerate; sandstone is grayish yellow green (5GY7/2); very fine- to fine-grained, subrounded, moderately well-sorted quartzarenite; micaceous; calcareous; conglomerate is grayish red (10R4/2) to pale reddish brown (10R5/4); sandstone is pale reddish brown (10R5/4) to moderate reddish orange (10R6/6); sandstone is fine-grained, subrounded, poorly sorted litharenite; conglomerate consists primarily of mudstone clasts 2-10 mm in diameter; some limestone and other clasts up to 35 mm in diameter; both are calcareous.
2	Sandstones; upper sandstone is grayish red (10R4/2); alternating sets of fine- and medium- to coarse-grained, subrounded litharenites; calcareous; middle sandstone is pale reddish brown (10R5/4) to pale red (10R6/2); very-coarse grained, rounded, litharenite in matrix of finer fine- to medium-grained sandstone; many of the large grains are mudstone or mudstone rip-ups; lower sandstone is pale red (10R6/2); fine-grained, rounded, moderately well-sorted litharenite; calcareous.
1	Mudstone; grayish red (10R4/2) fresh, weathering to pale reddish brown (10R5/4); bentonitic; not calcareous.

Section G

Measured near Placitas in the SW¼ SE¼ SW¼ sec. 1, T12N R4E. Strata dip 24° to S70°W.

unit	lithology	thickness (m)
	Chinle Group:	
	Agua Zarca Formation:	
4	Silty sandstone; pale greenish yellow (10Y8/2); very fine- to medium-grained, subangular, poorly sorted sublitharenite; sugary texture; calcareous.	not measured
	unconformity (Tr-3 unconformity of Pipringos and O'Sullivan, 1978)	
	Moenkopi Formation:	
	Anton Chico Member:	
3	Sandstone; pale reddish brown (10R5/4) and moderate reddish orange (10R6/6); fine-grained, subangular, moderately well-sorted litharenite; micaceous; calcareous; silty sandstone; pale greenish yellow (10Y8/2); very fine- to medium-grained, subangular, poorly sorted sublitharenite; sugary texture; calcareous.	6.8
2	Mudstone; mottled dark reddish brown (10R3/4) and pale greenish yellow (10Y8/2); calcareous.	6.8
	unconformity	
	San Andres Formation	
1	Limestone; yellowish gray (5GY6/1) fresh; weathers to light olive gray (5Y6/1); micrite.	not measured

Section H: Placitas samples

Due to cover and structural complexities we did not measure a complete stratigraphic section of the Chinle Group in the vicinity of Placitas. We have, however, sampled representative lithologies of the Moenkopi Formation and Chinle Group.

Moenkopi Formation: (NE¼ SW¼ SE¼ sec. 1, T12N, R4E).

Sandstone; pale reddish brown (10R5/4); fine- to medium-grained, rounded, well-sorted sublitharenite; slightly calcareous; some interbeds of mud- and siltstones of the same colors.

Conglomerate; medium gray (N5) to medium light gray (N6) fresh; stained to moderate reddish orange (10R6/6); clasts are well-rounded intraformational mudstone rip-ups that vary from 2 to 35 mm in diameter and are of typical Moenkopi lithologies and colors; very calcareous.

Chinle Group; Petrified Forest Formation (NW¼ NW¼ sec. 7 [unsurveyed] T12N, R5E)

Unionid bed; Siltstone and silty mudstone; weathers pale reddish brown (10R5/4), medium dark gray (N4) to dark gray (N3) fresh; numerous complete but distorted and/or recrystallized unionids; very calcareous.

Section I

Section measured near Cedar Crest from the NW¼ NE¼ sec. 15 to NE¼ SE¼ NE¼ sec. 15 T10N R5E. Section is overturned, with strata dipping 62° to N37°W.

unit	lithology	thickness (m)
	Chinle Group:	
	Agua Zarca Formation:	
4	Sandstone; very light gray (N8), fresh, weathers to dark gray (N3); fine- to medium-grained, subrounded, moderately well-sorted	

	litharenite; calcareous; much covered.	28.0+
unconformity (Tr-3 unconformity of Pipringos and O'Sullivan, 1978):		
Moenkopi Formation:		
Anton Chico Member:		
3	Siltstone (lower 8.4 m) and sandstone (upper 2.5 m); medium gray (N5) to pale red (5R6/2); very fine-grained, subangular, poorly sorted litharenite; ripple laminated; calcareous; interbedded with silty mudstone of identical colors.	10.9
2	Sandstone; grayish yellow green (5GY7/2); muddy; friable; medium- to coarse-grained, subangular, poorly sorted sublitharenite; calcareous.	0.3
unconformity:		
San Andres Formation:		
1	Limestone; medium dark gray (N4); muddy, micritic with very minor crinoid stems; some thin (1 mm or less) calcite veins.	not measured

Section J

Strata dip 42° to N80°E. Measured 9 August 1988 by S.G. Lucas and S.N. Hayden in the SW¼ SW¼ NW¼ of sec. 36, T11N R5E Bernalillo County.

unit	lithology	thickness (m)
Entrada Sandstone:		
9	Sandstone; yellowish gray (5Y8/1) fresh; weathers to light brown (5YR6/4) with darker spots; fine-grained, subangular, well-sorted quartzarenite; some stringers of coarser sand that are resistant; jointed; massive.	3.0+
unconformity (J-2 unconformity of Pipringos and O'Sullivan, 1978): fault?		
Chinle Group:		
Petrified Forest Formation:		
8	Silty sandstone; grayish orange pink (5YR7/2); very fine-grained, subrounded, moderately well-sorted sublitharenite; laminar; calcareous.	0.3
7	Shale and sandy siltstone; laminae are bands of pale reddish brown (10R5/4) and moderate reddish orange (10R6/6); bentonitic; calcareous.	0.5
6	Sandstone; pale greenish yellow (10Y8/2), mottled and stained to pale reddish brown (10R5/6); fine- to medium-grained, subangular, moderately poorly sorted quartzarenite; some trough crossbeds; much jointed; well-indurated; 0.3-1.0 m of scour at base; calcareous.	8.3
5	Muddy sandstone; pale reddish brown (10R5/4); lithic wackestone to sandy mudstone; laminar; bentonitic.	5.3
4	Mudstone; pale reddish brown (10R5/4); bentonitic; blocky; calcareous.	2.1
3	Siltstone; mottled light greenish gray (5GY8/1) and pale reddish brown (10R5/4); numerous calcrete nodules up to 6 cm in diameter; nodules are stained pale reddish brown (10R5/4); forms a slope.	1.4
2	Siltstone; pale reddish brown (10R5/4); slightly sandy; blocky; indurated ledge-former.	1.3
1	Interbedded thin, laminar sandstones and siltstone; grayish red (10R4/3) to pale reddish brown (10R5/4) with some pale red (10R6/2) siltstone; sandstones are very fine- to fine-grained, subrounded, moderately well-sorted sublitharenite; sandstone is not calcareous, some siltstones are calcareous.	5.0+

Section K: Samples from Moenkopi and Agua Zarca Formations

Samples collected in NW¼ NW¼ SE¼ sec. 35 T11N R5E at Cañoncito in creek bed.

unit	lithology
Agua Zarca Formation:	
4	Sandstone; yellowish gray (5Y7/2) fresh; weathers to pale red (10R6/2); dominantly fine- to medium-grained, sometimes coarser, rounded, well-sorted; calcareous.
3	Silty sandstone and sandy siltstone; yellowish gray (5Y7/2) to grayish yellow green (5GY7/2); sandstone is very fine- to fine-grained, subrounded sublitharenite; very micaceous; not calcareous.
Moenkopi Formation:	
2	Sandstone; grayish red (5R4/2); fine-grained, subrounded, moderately well-sorted litharenite; micaceous; calcareous.
1	Sandstone; grayish red (5R4/2) to pale red (5R6/2); very fine-grained, subrounded, well-sorted litharenite; laminar; extremely well-indurated, not calcareous.

Section L: Miscellaneous samples in vicinity of Cedar Crest

Locations: A: Sandia Knolls, NW¼ SW¼ SW¼ sec. 21 T11N R6E. B: NE¼ NE¼ SE¼ sec. 24 T11N, R5E, on road west of Antonito, C: NW¼ SE¼ NW¼ sec. 28 T11N R6E along NM-44.

Descriptions:

A. Agua Zarca Formation: Sandstone; grayish yellow (5Y8/4) to yellowish gray (5Y7/2); fine- to medium-grained, rounded, well-sorted quartzarenite; well-indurated quartz cement; not calcareous.

B. Agua Zarca Formation: Sandstone; pale greenish yellow (10Y8/2) fresh, weathers to grays and blacks; medium-grained, subrounded, well-sorted sublitharenite; very well indurated; quartz cement; not calcareous.

C1. Petrified Forest Formation: Muddy sandstone; grayish red (10R4/2) to pale reddish brown (10R5/4); fine-grained, subangular, moderately well-sorted litharenite; weakly calcareous.

C2. Petrified Forest Formation: Sandstone and mudstone-pellet conglomerate; sandstone and matrix are light olive gray (Y6/1); clasts are grayish red (10R4/2); sandstone varies from fine-grained, subangular, moderately well-sorted litharenite to coarse- to very coarse-grained, subangular, moderately poorly sorted litharenite; calcareous.