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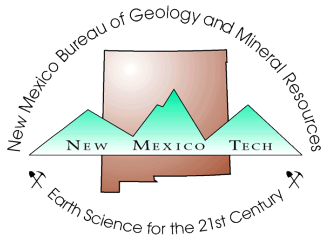

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Type and reference sections of the Tucumcari, Mesa Rica and Pajarito formations, Cretaceous of east-central New Mexico

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Introduction

The Lower Cretaceous strata of east-central New Mexico (parts or all of Mora, Quay, Guadalupe, Harding, San Miguel and Union Counties) were first studied by Jules Marcou in 1853. However, basic problems of lithostratigraphy and biostratigraphy have continued to plague workers investigating these rocks. As part of an effort to alleviate these problems, we designate and describe type and reference sections for the Tucumcari, Mesa Rica and Pajarito formations, three long-recognized units of late Albian age in east-central New Mexico (Fig. 1). We also discuss briefly the nomenclature of Lower Cretaceous strata in east-central New Mexico. Rock colors used in this paper are those of Goddard et al. (1948).

Tucumcari Shale

Marcou (1889, pp. 364–365) first used the term "Tucumcari Beds" to refer to fossiliferous strata containing "*Grypaea dilatata* var. *tucumcarii*" (=*Texigryphaea tucumcarii*) and "*Ostrea marshii*" (=*Lopha subovata*) that he considered to be of Jurassic age. As Kues (1985) noted, Marcou (1889) clearly, though not explicitly, applied this term to the "Jurassic" strata exposed at Pyramid Mountain southwest of Tucumcari, "beds B–F" of his earlier illustration (Marcou, 1858) of the Jurassic section at Pyramid Mountain (Kues, 1985, fig. 6). Cummins (1892, p. 202) subsequently applied the term "Tucumcari Beds" to strata at Tucumcari Mountain that are essentially correlative with Marcou's "Tucumcari Beds" at Pyramid Mountain, 21 km to the southwest. Later workers, such as Fay (1975), have erroneously believed Tucumcari Mountain to be the type locality of *T. tucumcarii* (Kues, 1985). However, contrary to Wilmarth (1938, p. 2190), Cummins' (1892) use of "Tucumcari Beds" was not the first proposal of the rock-stratigraphic unit now termed Tucumcari Shale, although

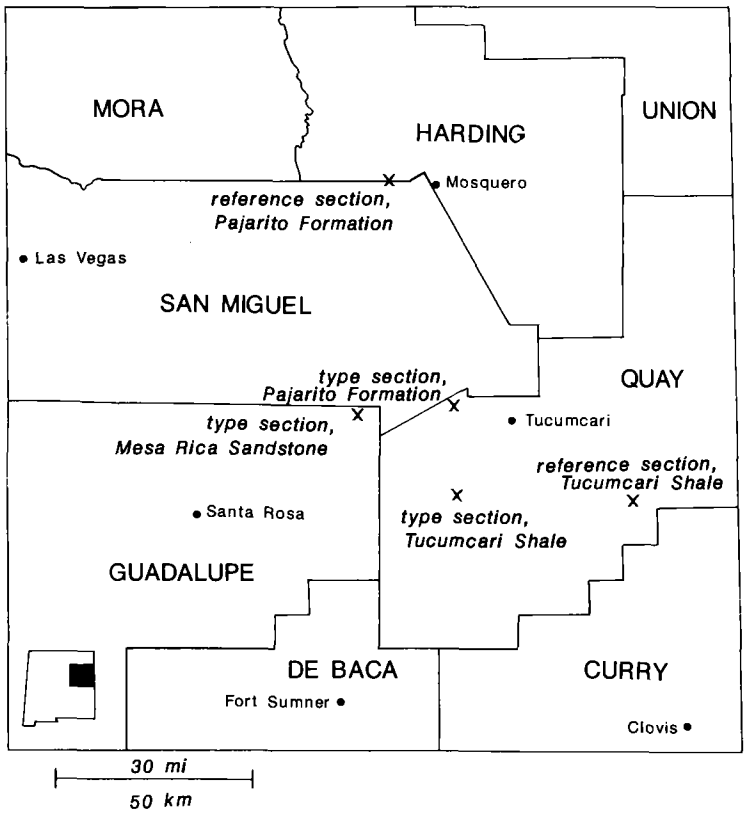

FIGURE 1—Map of east-central New Mexico showing locations of type and reference sections of the Tucumcari and Pajarito formations and type section of the Mesa Rica Sandstone.

TABLE 1—Type section of Tucumcari Shale. Measured on the northwestern edge of Pyramid Mountain near its summit in the SE¼ SW¼ sec. 19, T9N, R29E.

Unit	Lithology	Thickness (m)
	Mesa Rica Sandstone	
14	Sandstone, pale yellowish-orange (10 YR 8/6) and dark yellowish-orange (10 YR 6/6), weathers to very light gray (N 8), quartzose, fine-grained, subangular to subrounded, well-sorted; clay cement; lower portion laminar and overlain by beds with low-angle crossbeds, intensively bioturbated at top.	3.0+
	Tucumcari Shale	
13	Shale, medium-gray (N5), weathers to light olive brown (5 Y 5/6), calcareous, slightly sandy; sand is very fine grained.	1.3
12	Sandstone and mudstone. Sandstone is pale yellowish brown (10 YR 6/2) to moderate yellowish brown (10 YR 5/4), weathers to dark yellowish orange (10 YR 6/6) and very light gray (N 8), fine-grained, subangular, well-sorted, well-indurated; silica cement with minor amount of limonitic cement. Mudstone is yellowish orange (10 YR 8/6), weathers to grayish orange (10 YR 7/4), limonitic, very calcareous; contains very fine grained sand, which is subrounded to rounded quartz; trace of glauconite.	0.23
11	Shale, light olive-gray (5 YR 6/1), very slightly calcareous, slightly silty.	0.66
10	Sandstone, muddy, dark yellowish-orange (10 YR 6/6), weathers to pale yellowish orange (10 YR 8/6), quartzose, subangular to subrounded, very poorly sorted, calcareous, well-indurated, very fine to fine-grained, massive.	0.98
9	Sandy mudstone, light olive-gray (5 YR 6/1), weathers to light brown (5 YR 5/6) and grayish orange (10 YR 7/4), very calcareous, slightly carbonaceous; sand is fine to very fine grained, rounded to subrounded quartz.	1.3
8	Silty mudstone, light olive-gray (5 YR 6/1), weathers to dark yellowish orange (10 YR 6/6), limonitic, calcareous, slightly carbonaceous.	0.13
7	Silty mudstone, moderate yellowish-brown (10 YR 5/4), weathers to dark yellowish orange (10 YR 6/6), limonitic, calcareous; no carbonaceous debris.	2.9
6	*Texigryphaea* horizon in same lithology as unit 5. This is the unit from which Marcou's holotype of *T. tucumcarii* and the UNM topotypes were derived.	0.49
5	Silty shale, pale-olive (10 YR 6/2), very calcareous; some liminotic stains; trace of carbonaceous debris; comminuted fragments of *Texigryphaea*.	0.25
4	Silty mudstone, pale grayish-yellow (5 YR 8/4), weathers to greenish yellow (10 Y 8/2), limonitic, calcareous; trace of carbonaceous debris; comminuted shell fragments to *Texigryphaea*.	0.15
3	Shale, gray (N 5) to light olive-gray (5 Y 6/1), weathers to dark yellowish orange (10 YR 6/6), limonitic, very slightly calcareous, carbonaceous.	0.49
2	Silty shale, greenish-gray (5 GY 6/1), weathers to pale yellowish orange (10 YR 8/6), limonitic, noncalcareous; trace of carbonaceous debris; some selenite crystals.	0.05
	Total	**8.93**
	Morrison Formation	
1	Sandstone, pale yellowish-orange (10 YR 8/6) to dark yellowish-orange (10 YR 2/2), quartzose, limonitic, kaolinitic, fine-grained, subrounded, well-sorted, laminar.	2.0+

he did correctly identify the age of this unit as Cretaceous instead of Jurassic, and no type locality of the Tucumcari Shale has ever been formally designated. Because Marcou (1889) first attached the name Tucumcari to the unit now termed Tucumcari Shale at Pyramid Mountain (also see Kues, 1985, and Kues and Kietzke, 1985), we designate this section the type section of the Tucumcari Shale.

The type section of the Tucumcari Shale (Figs. 1, 2, Table 1) is on the northwestern face of Pyramid Mountain. Here, the Tucumcari Shale is about 9 m thick and consists of interbedded olive-gray to yellowish-brown silty to sandy mudstone (50%), gray to light olive-gray shale (27%), yellowish-brown and yellowish-orange muddy sandstone (13%), and greenish-gray to pale-olive silty shale (9%).

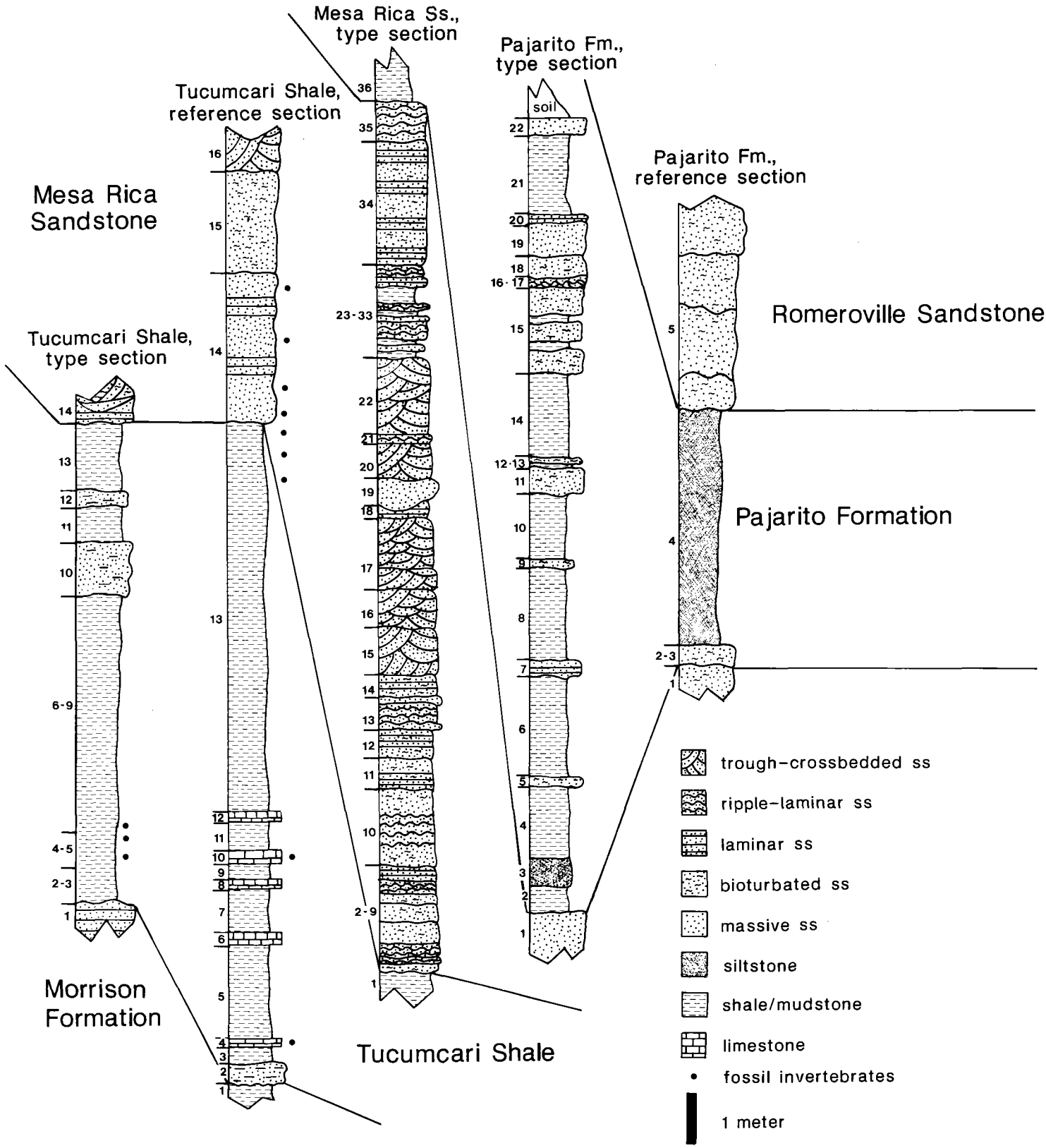

FIGURE 2—Type and reference sections of the Tucumcari Shale, type section of the Mesa Rica Sandstone and type and reference sections of the Pajarito Formation. See Fig. 1 for locations of sections and Tables 1–5 for descriptions of lithologic units.

TABLE 2—Reference section of Tucumcari Shale. Measured at "San Jon Hill" in the SE¼ sec. 19, T9N, R31E.

Unit	Lithology	Thickness (m)
	Mesa Rica Sandstone	
16	Sandstone, moderate yellowish-green (10 GY 6/4) and bluish-white (5 B 9/1), weathers to olive gray (5 Y 4/1), quartzose, very calcareous, fine- to medium-grained, angular to subrounded, moderately poorly sorted, trough-crossbedded; some iron oxide stains.	1.6+
15	Sandstone, dark yellowish-orange (10 YR 6/6) to pale yellowish-orange (10 YR 8/6), weathers to very light gray (N 8), quartzose, fine-grained, subangular to subrounded, moderately well sorted, intensively bioturbated; some yellowish clay cement.	3.8
14	Sandstone, grayish-yellow (5 Y 8/4), weathers to dark yellowish orange (10 YR 6/6), quartzose, kaolinitic, limonitic, generally fine to medium grained but about 5% is very coarse grained, subangular to subrounded, poorly sorted; some parallel laminae but generally massive; much shell debris (generally 5 to 7 mm in diameter) and some complete shells of *Lopha*, *Scabrotrigonia* and other molluscs.	5.6
	Tucumcari Shale	
13	Shale, same lithology as unit 3; upper 3 m fossiliferous, containing shells of *T. tucumcarii*, *Scabrotrigonia emoryi* and other molluscs.	14.5
12	Limestone, same lithology as unit 4.	0.3
11	Shale, same lithology as unit 3.	1.2
10	Limestone, same lithology as unit 4, contains shells of *T. tucumarii*	0.4
9	Shale, same lithology as unit 3.	0.6
8	Limestone, same lithology as unit 4.	0.3
7	Shale, same lithology as unit 3.	1.7
6	Limestone, same lithology as unit 4.	0.4
5	Shale, same lithology as unit 3.	3.6
4	Limestone, greenish-gray (5 GY 6/1), weathers to dark yellowish brown (10 YR 4/2), micritic, fossiliferous; some limonitic stains; some clay.	0.1
3	Shale, olive-black (5 Y 2/1), very slightly calcareous.	0.8
2	Muddy sandstone, grayish-orange (10 YR 7/4) and greenish-black (5 GY 2/1), quartzose, about 60% sand and 40% mud, fine-grained, angular, fairly well sorted; cobbles in matrix are chert, jasper, quartzite, largest is 15 × 7 mm.	0.8
	Total	**24.7**
	Morrison Formation	
1	Silty claystone, light greenish-gray (5 GY 8/1) with limonitic stains that are moderate brown (5 YR 4/4) to dark yellowish orange (10 YR 6/6), micaceous and slightly dolomitic.	1.0+

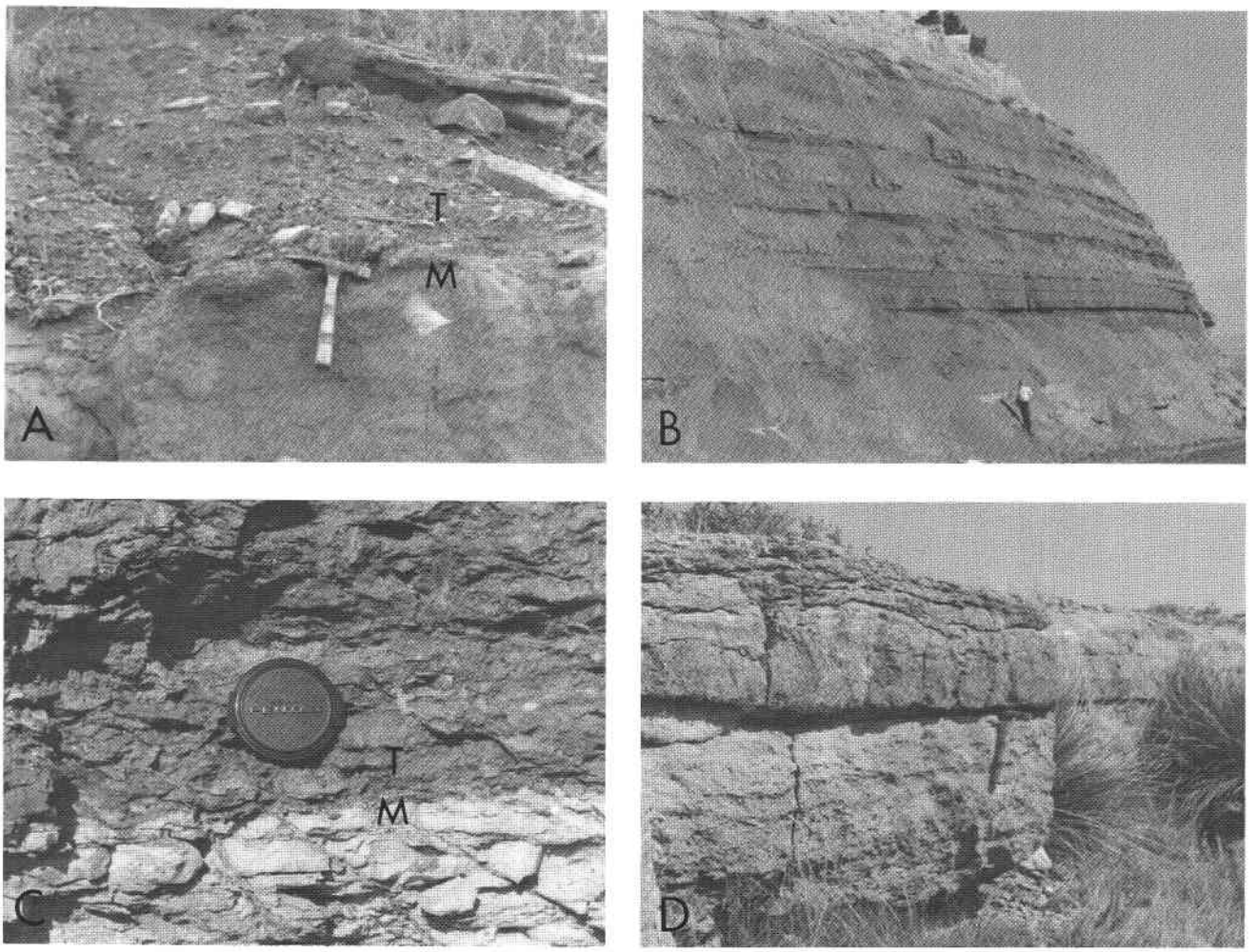

FIGURE 3—Selected strata at the type and reference sections of the Tucumcari Shale. **A**, Uppermost Morrison Formation sandstone (M) overlain by basal shale of Tucumcari Shale (T) at Pyramid Mountain. **B**, Overview of reference section of Tucumcari Shale at "San Jon Hill." Light-colored bed to left of man is uppermost claystone of Morrison Formation; light-colored sandstone at top of photograph is base of Mesa Rica Sandstone. **C**, Close-up of Morrison (M)–Tucumcari (T) contact at "San Jon Hill." **D**, Lowermost sandstone of Mesa Rica Sandstone (below hammerhead) at "San Jon Hill," the fossiliferous sandstone included by some workers in the Tucumcari Shale.

About 1 m above the base of the Tucumcari Shale at Pyramid Mountain is a *Texigryphaea* horizon (Fig. 3A), the source of Marcou's (1855, pl. 21, fig. 3) holotype of *Texigryphaea tucumcarii* and the UNM topotypes of this species (Kues et al., 1985). At its type section, silty shale of the Tucumcari Shale rests on quartzose sandstone that we assign to the Morrison Formation (Payne et al., 1986). Quartzose, unfossiliferous sandstone of the Mesa Rica Sandstone overlies calcareous shale of the Tucumcari Shale at Pyramid Mountain.

This type section of the Tucumcari Shale at Pyramid Mountain is a relatively thin sequence of the Tucumcari with only one invertebrate fossil-producing horizon. Therefore, we designate the thicker, more fossiliferous section of the Tucumcari Shale at "San Jon Hill" a reference section of the Tucumcari Shale (Figs. 1, 2, 3B, Table 2). This section is located in an east-facing cut of NM–39 and was described by Brooks (1959), Scott (1970), Brand and Mattox (1972), and Jacka and Brand (1973). Here, the Tucumcari Shale is about 14 m of olive-gray to black shale with six intercalated, thin (0.1–0.5 m) beds of gray to brown limestone. The main fossiliferous horizon is 6.1 m above the base of the Tucumcari, but fossils occur at several other layers above and below this level (Fig. 2). At "San Jon Hill" the Tucumcari Shale rests on greenish-gray claystone of the Morrison Formation (Fig. 3C). Rounded chert and jasper pebbles in the Tucumcari immediately above this claystone have been interpreted as a thin, reworked zone of pebbles derived from the Morrison (Jacka and Brand, 1973).

At the reference section, the Tucumcari Shale is overlain by the Mesa Rica Sandstone. We have placed the Tucumcari–Mesa Rica contact at the base of a 5.6-m-thick massive to laminar sandstone that contains much shell debris, especially of *Lopha* and *Scabrotrigonia* (Fig. 3D). Griggs and Read (1959) also assigned this fossiliferous sandstone to the Mesa Rica, although Scott (1970) and Mateer (1985, 1987) included it in the Tucumcari Shale. We include this sandstone in the Mesa Rica because the lithologic break from shale (Tucumcari) to sandstone (Mesa Rica) forms the most readily mappable boundary between two lithostratigraphic units. Scott (1970) and Mateer (1985, 1987) noted that the lowermost sandstone of the Mesa Rica as we define it at "San Jon Hill" contains an invertebrate megafauna typical of the Tucumcari Shale and lies beneath an unconformity that they believe represents a significant marine regression. Although both Scott and Mateer used these observations to support inclusion of this sandstone in the Tucumcari Shale, we do not believe the age of a unit or the sedimentological interpretation of an unconformity (which, in this case, is open to debate: Kisucky, 1987; Kues and Lucas, 1987) should be used to define lithostratigraphic units.

Mesa Rica Sandstone

Dobrovolny and Summerson (in Dobrovolny et al., 1946) named the Mesa Rica Sandstone without designating or describing a type section. They referred to the Mesa Rica as "a white or brownish-buff, cross-bedded, medium- or coarse-grained sandstone that is massive or cliff forming" and also noted that "locally, lenses of quartz-pebble conglomerate occur at the base." Clearly, Dobrovolny and Summerson named the Mesa Rica Sandstone for Mesa Rica, a large mesa in northeastern Guadalupe County and southeastern San Miguel County.

We designate a type section of the Mesa Rica Sandstone on the southwestern face of Mesa Rica (Figs. 1, 2, 4A, Table 3). Here, the Mesa Rica is 24.5 m thick and consists of two sandstone intervals separated by light-gray and purple, variegated mudstone. The lower sandstone interval is 17.4 m thick and rests with apparent conformity on the Tucumcari Shale. Yellowish-brown and yellowish-orange, very fine to fine-grained quartzarenite dominates this lower interval of the Mesa Rica and displays a variety of bedforms (Fig. 2, Table 3). The thin (~2 m) mudrock-dominated interval above this lower sandstone is lithologically identical to some strata of the Pajarito Formation. Sandstone above this mudrock interval is 4.6 m of dominantly fine- to medium-grained, yellowish-brown, bioturbated quartzarenite. The Mesa Rica–Pajarito contact is chosen at the base of a gray

TABLE 3—Type section of Mesa Rica Sandstone. Measured in the NW1/4NW 1/4 sec. 5, T11N, R26E.

Unit	Lithology	Thickness (m)
	Pajarito Formation	
36	Mudstone, light-gray (N7), slightly calcareous, mostly covered.	1.0+
	Mesa Rica Sandstone	
35	Sandstone, very pale orange (10 YR 8/2), and moderate yellowish-brown (10 YR 6/6), weathers to light brown (5 YR 5/6), quartzose, fine-grained, subangular to subrounded, well-sorted, ripple-laminated.	1.1
34	Sandstone, very pale orange (10 YR 8/2) to pale red-purple (5 RP 6/2), weathers to light brown (5 YR 6/4), quartzose, medium- to fine-grained, subangular to subrounded, moderately well sorted, parallel-laminated, bioturbated, friable; kaolinitic cement; some hematitic grain coating.	3.5
33	Sandstone, moderate yellowish-brown (10 YR 5/4) to grayish red-purple (5 RP 4/2) and medium light-gray (N6), weathers to pinkish gray (5 YR 8/1), quartzose, medium- to fine-grained, subangular to subrounded, ripple-laminated; moderately poorly sorted clay and hematite cement; slightly calcareous on weathered surface.	0.3
32	Sandstone, medium-gray (N5), weathers to pinkish gray (5 YR 8/1) and light brown (5 YR 5/6), parallel-laminated; trace carbonaceous material; trace mica; some hematite and limonite staining.	0.2
31	Mudstone, medium dark gray (N4), limonitic-stained, carbonaceous, parallel-laminated, silty, firm.	0.55
30	Sandstone, very light gray (N 8), weathers to pinkish gray (5 YR 8/1), quartzose, very fine to fine-grained, subrounded to rounded, moderately well sorted, ripple laminar to laminar; kaolinitic cement; trace disseminated hematite.	0.15
29	Sandy siltstone, light brownish-gray (5 YR 6/1), weathers to pale red purple (5 RP 6/2), firm; very fine sand; hematite staining.	0.2
28	Sandy mudstone, grayish red-purple (5 RP 4/2), weathers to pale pink (5 RP 8/2), slightly carbonaceous.	0.5
27	Sandstone, very pale orange (10 YR 8/2) to pale yellowish-orange (10 YR 8/6), weathers to moderate yellowish brown (10 YR 3/4) and very dusky red (10 R 2/2), quartzose, medium- to fine-grained, subangular to angular, moderately well sorted, ripple-laminar, friable; slight hematitic staining.	0.5
26	Sandstone, greenish-gray (10 GY 6/1), pale yellowish-orange (10 YR 8/6), and dusky yellowish-brown (10 YR 2/2), weathers to pale yellowish brown (10 YR 6/2), quartzose, limonitic, kaolinitic, fine-grained, round to subround, moderately well sorted, laminar and ripple-laminar.	0.5
25	Muddy sandstone, light-gray (N7), weathers to yellowish gray (5 Y 8/1), quartzose, slightly carbonaceous, slightly calcareous, very fine grained, subround to round, moderately well sorted, laminar; trace of hematite.	0.2
24	Sandstone, pale yellowish-orange (10 YR 8/6) to moderate yellowish-brown (10 YR 5/4), weathers to very pale orange (10 YR 8/2) and grayish red purple (5 RP 4/2), quartzose, limonitic, kaolinitic, medium- to fine-grained, subangular to angular, moderately well sorted, laminar, friable.	0.2
23	Sandy mudstone, medium light-gray (N 6), weathers to very light gray (N 8), slightly calcareous, very slightly carbonaceous, hematitic.	0.1
22	Sandstone, very pale orange (10 YR 8/2) to grayish-orange (10 YR 7/4), quartzose, medium- to fine-grained, subangular to subround, well-sorted, planar-bounded trough-cross-bedded; trace kaolinite cement; trace limonite cement.	2.3
21	Sandstone, very pale orange (10 YR 8/2) to moderate orange-pink (5 YR 8/4), weathers to light brown (5 YR 6/4), quartzose, slightly limonitic, medium-grained, subangular to well-rounded, well-sorted, ripple-laminated; kaolinite cement.	0.1
20	Sandstone, moderate orange-pink (5 YR 8/4), weathers to grayish orange (10 YR 7/4) and light greenish gray (5 GY 8/1), quartzose, slightly kaolinitic, medium-grained, subangular to well-rounded, well-sorted, planar-bounded trough-crossbedded.	1.2
19	Sandstone, very pale orange (10 YR 8/2) to grayish-orange (10 YR 7/4), weathers to moderate yellowish brown (10 YR 5/4), quartzose, kaolinitic, medium- to fine-grained, subangular to well-rounded, well-sorted, massive; trace hematite.	0.5

TABLE 3 (continued)

Unit	Lithology	Thickness (m)
18	Sandstone, very light gray (N 8), weathers to grayish orange (10 YR 7/4), quartzose, very kaolinitic, fine- to medium-grained, subangular to subround, moderately well sorted, laminar.	0.6
17	Sandstone, very pale orange (10 YR 8/2), weathers to greenish gray (5 GY 6/1), quartzose, slightly limonitic, kaolinitic, fine- to medium-grained, subangular to subround, moderately well sorted, trough-crossbedded, friable.	2.0
16	Sandstone, very pale orange (10 YR 8/2), weathers to greenish gray (5 GY 6/1), quartzose, limonitic, kaolinitic, fine- to medium-grained, subangular to subround, moderately well sorted, firm, trough-crossbedded.	1.1
15	Sandstone, pale yellowish-orange (10 YR 8/6), weathers to yellowish gray (5 Y 8/1), quartzose, slightly kaolinitic, slightly limonitic, medium to very fine grained, subangular to well rounded, moderately poorly sorted, trough-crossbedded; trace of hematite.	1.3
14	Sandstone, very pale orange (10 YR 8/2), weathers to moderate yellowish brown (10 YR 5/4) and dusky yellowish brown (10 YR 2/2), quartzose, slightly limonitic, kaolinitic, medium to very fine grained, subangular to angular, moderately to poorly sorted, laminar and bioturbated.	0.7
13	Sandstone, very pale orange (10 YR 8/2), weathers to light brown (5 YR 6/4), quartzose, kaolinitic, fine-grained, subangular to subround, moderately well sorted, ripple-laminar; trace of limonite.	0.8
12	Sandstone, very pale orange (10 YR 8/2) to grayish-orange (10 YR 7/4), weathers to light brown (5 YR 6/4) and dusky brown (5 YR 2/2), quartzose, kaolinitic, fine to very fine grained, subround to round, moderately well sorted, laminar, bioturbated; trace of limonite.	0.9
11	Sandstone, very pale orange (10 YR 8/2), weathers to light brown gray (5 YR 6/1) and dark gray (N3), quartzose, very slightly carbonaceous, very kaolinitic, fine to very fine grained, subround to round, moderately poorly sorted, laminar, bioturbated.	0.9
10	Sandstone, pale yellowish-orange (10 YR 8/6) to grayish-orange (10 YR 7/4), weathers to pale yellowish brown (10 YR 6/2), quartzose, limonitic, calcareous, hematitic, fine-grained, subangular to rounded, well-sorted, massive to ripple-laminar, bioturbated, firm.	2.1
9	Sandstone, pale yellowish-orange (10 YR 8/6), quartzose, limonitic, slightly calcareous, very slightly carbonaceous, fine to very fine grained, subround to well rounded, massive, laminar, bioturbated.	0.5
8	Sandstone, moderate yellowish-brown (10 R 5/4), weathers to light brown (5 YR 5/6) and very dusky red (10 YR 2/2), quartzose, very limonitic, hematitic, fine-grained, subangular to subround, moderately well sorted, ripple-laminated.	0.3
7	Sandstone, very light gray (N 8), weathers to moderate yellowish brown (10 YR 5/4), quartzose, slightly kaolinitic, very fine grained, subangular to subround, well sorted, massive, bioturbated.	0.3

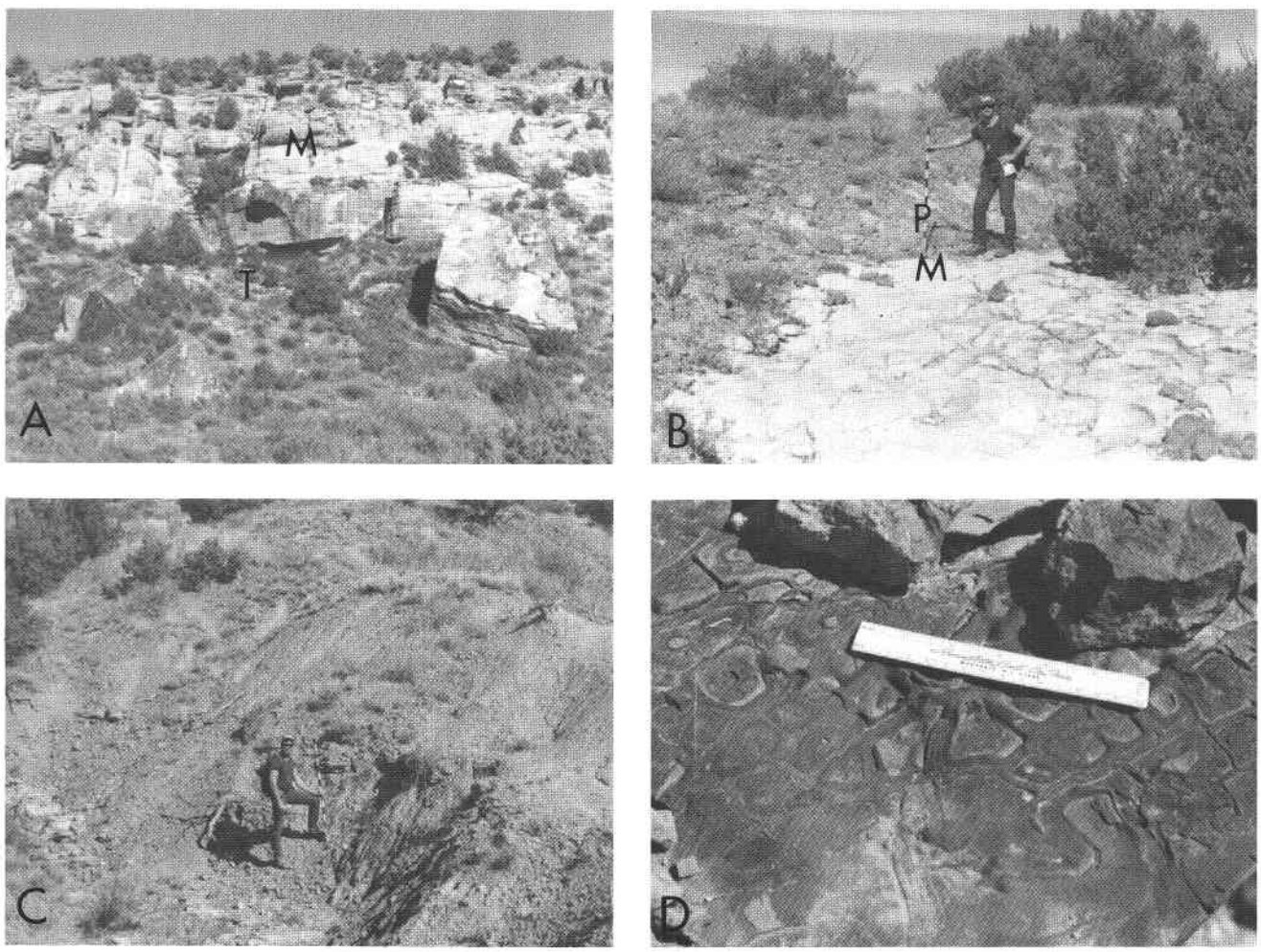

FIGURE 4—Type sections of the Mesa Rica and Pajarito formations. **A**, Overview of type section of Mesa Rica Sandstone (M) above covered slope of Tucumcari Shale (T). **B**, Top sandstone of the Mesa Rica Sandstone (M) overlain by basal mudstone of the Pajarito formation (P) at the type section of the Pajarito Formation. **C**, Typical mudstone, siltstone, shale and thin sandstone of the lower part of the Pajarito Formation at its type section. **D**, Heavily oxidized, mudcracked sandstone (unit 17) at the type section of the Pajarito Formation.

TABLE 3 (continued)

Unit	Lithology	Thickness (m)
6	Sandstone, pale yellowish-orange (10 YR 8/6), quartzose, limonitic, kaolinitic, fine to very fine grained, subround to well rounded, moderately well sorted, massive, bioturbated.	0.5
5	Sandstone, pale yellowish-orange (10 YR 8/6), quartzose, kaolinitic, limonitic, fine to very fine grained, subround to round, moderately well sorted, massive, bioturbated.	0.6
4	Sandstone, moderate reddish-brown (10 R 4/6) to light-brown (5 YR 5/6), quartzose, limonitic, kaolinitic, hematitic, fine-grained, subangular to subround, moderately well sorted, massive, ripple-laminar.	0.4
3	Sandstone, light-gray (N7), dark yellowish-orange (10 YR 6/6), and pale reddish-brown (10 R 5/4), quartzose, limonitic, fine-grained, subangular to subround, moderately well sorted, massive, ripple-laminar.	0.1
2	Sandstone, yellowish-gray (5 Y 8/1), weathers to dusky yellowish green (5 GY 5/2), quartzose, limonitic, fine to very fine grained, subangular to subround, well-sorted, massive, bioturbated.	0.3
	Total	**25.7**
	Tucumcari Shale	
1	Shale, medium light-gray (N 6), mostly covered by soil and vegetation.	not measured

mudstone at the bottom of a mudrock-dominated section that, nevertheless, contains numerous lenticular quartzarenite beds, some as much as 1.5 m thick.

Pajarito Formation

Dobrovolny and Summerson (in Dobrovolny et al., 1946) originally described the Pajarito Shale as "soft brown sandstone alternating with gray shale that contains *Ostrea quadriplicata*." Although Dobrovolny et al. (1946) mapped the distribution of the Pajarito Shale in much of Quay County and identified it in three measured stratigraphic sections, they did not designate or describe a type section. The name Pajarito Shale is from Pajarito Creek, an intermittent stream in eastern Guadalupe County that joins the Canadian River in the Pablo Montoya Grant of eastern San Miguel County. Because stratigraphic sections we have measured in the Pajarito "Shale" contain relatively little shale (they are dominated by sandstone, mudstone, and siltstone), we advocate use of Pajarito Formation instead of Pajarito Shale.

We designate a type section of the Pajarito Formation at the head of a tributary of Hondo Canyon just south of Mesa Rica (Figs. 1, 2, 4B–D, Table 4). This type section is within the drainage basin of Pajarito Creek, is easily accessible, and encompasses a relatively thick, well-exposed, and lithologically characteristic sequence of the Pajarito Formation. However, because the top of the Pajarito Formation is not exposed at its type section, we designate a reference

TABLE 4—Type section of Pajarito Formation. Measured in the NW¼SE¼ NE¼ sec. 6, T11N, R29E.

Unit	Lithology	Thickness (m)
	Quaternary soil	
	disconformity	
	Pajarito Formation	
22	Sandstone, grayish-brown (5 YR 3/2), quartzose, noncalcareous, fine-grained, subangular to angular, poorly sorted, well-indurated, massive (intensively bioturbated); cement is iron rich; small fractures (about 3 mm wide) filled with calcite.	0.5+
21	Silty shale, light-gray (N7), trace of carbonaceous debris and quartz sand, very fine grained, well-rounded, slightly micaceous; mottled in hematitic portions to dusky red (5 R 3/4).	3.0
20	Sandstone, grayish-orange (10 YR 7/4) and very light gray (N 8), quartzose, fine- to medium-grained, subangular to angular, moderately well sorted, hematitic, well-indurated; limonitic and kaolinitic cement; 0.3–0.5-mm-thick laminae; parting lineations.	0.3
19	Silty sandstone, pale red-purple (5 RP 6/2) and grayish-orange (10 YR 7/4), quartzose, calcareous, very fine to medium grained, angular to subrounded, poorly sorted, massive (intensively bioturbated); iron oxide and hydroxide cements.	1.3
18	Silty sandstone, mottled light olive gray (5 Y 6/1) and pale yellowish brown (10 YR 6/2), quartzose, subangular to round, very fine grained, moderately well sorted, intensively bioturbated; iron cement.	0.8
17	Sandstone, very dusky red (10 R 2/2) to blackish-red (5 R 2/2), quartzose, calcareous, fine-grained, subrounded to well-rounded, moderately well sorted; silica and iron oxide/hydroxide cement; ripple-laminated (17–18 cm between rippled crests) with mudcracks on top bedding plane.	0.07
16	Sandstone, very pale orange (10 YR 8/2) and pale yellowish-brown (10 YR 6/2), quartzose, medium-grained, subangular to subround, well-sorted; limonitic cement; small scale trough crossbeds.	0.13
15	Sandstone and interbedded silty shale. Sandstone is pale yellowish orange (10 YR 8/6), quartzose, noncalcareous, fine-grained, subrounded, well-sorted, heavily bioturbated; trace of fine manganese stain. Silty shale is light gray (N 7), calcareous, micaceous; intercalated with sandstone in 0.3-m-thick beds.	3.3
14	Sandy mudstone, yellowish-gray (5 Y 8/1) to medium light-gray (N 6), slightly limonitic, noncalcareous; sand is fine quartz.	3.2
13	Sandstone, very pale orange (10 YR 8/2), grayish-orange (10 YR 7/4) and dark yellowish-orange (10 YR 6/6), quartzose, fine- to medium-grained, angular to subangular, moderately sorted, intensively bioturbated; some limonitic cement.	0.2
12	Sandy shale, medium-gray (N5), noncalcareous; sand is very fine quartz.	0.1
11	Sandstone, dark yellowish-orange (10 YR 6/6), grayish-orange (10 YR 7/4), and very pale orange (10 YR 8/2), quartzose, fine-grained, angular to subangular, moderately sorted, sparsely bioturbated.	1.0
10	Sandy shale, same lithology as unit 6.	2.5
9	Sandstone, very dark red (5 R 2/6) to dusky-red (5 R 3/4), quartzose (about 15% plagioclase), slightly micaceous, well-sorted, very fine grained, angular to subangular, intensively bioturbated; hematitic cement.	0.2
8	Sandy shale, medium light-gray (N 6) with bands of moderate red (5 R 4/6), noncalcareous, micaceous; trace of iron; sand is fine quartz.	3.6
7	Muddy sandstone, dark yellowish-orange (10 YR 6/6) to moderate yellowish-brown (10 YR 5/4), limonitic, litharenite, fine-grained, noncalcareous, micaceous and iron-rich; parallel laminae; parting lineations.	0.25
6	Shale, dusky yellowish-brown (10 YR 2/2) to olive-black (5 YR 2/1), noncalcareous, micaceous.	3.8
5	Muddy sandstone, dark yellowish-orange (10 YR 6/6) to pale yellowish-brown (10 YR 6/2), quartzose, limonitic, very fine to fine grained, subround to subangular, moderately well sorted; some carbonaceous flecks; crude parallel laminae but intensively bioturbated.	0.3
4	Sandy mudstone, light-gray (N 7), noncalcareous; sand is very fine quartz.	2.8
3	Sandy siltstone, medium-gray (N5), weathers to dark yellowish orange (10 YR 6/6), slightly calcareous; sand is very fine quartz.	1.0
2	Mudstone, mottled light olive gray (5 Y 6/1), pale olive (10 R 6/2), and moderate reddish brown (10 R 4/6), slightly calcareous.	1.0
	Total	**29.35+**
	Mesa Rica Sandstone	
1	Sandstone, banded very dark red (5 R 2/6), moderate red (5 R 4/6), and moderate pink (5 R 7/4) to grayish orange pink (10 R 8/2), quartzose, fine- to medium-grained, subangular, moderately sorted, intensively bioturbated; hematitic/kaolinitic cement.	0.8+

section of the Pajarito Formation along a tributary of Burro Creek, Harding County (Figs. 1, 2, Table 5).

At its type section the Pajarito Formation is at least 29 m of interbedded yellowish-orange and brown, quartzose, generally bioturbated sandstone and light-gray silty shale/mudstone. Dominant lithologies are sandy shale (24% of the type section), sandy mudstone (23%), and sandstone (19%). The Mesa Rica–Pajarito contact is picked here, as at other sections, at the change from a sandstone-dominated section (~100% sandstone) to a section with significant intervals of shale and mudstone (Pajarito). At its reference section the Pajarito Formation is 10.5 m of medium-gray sandy siltstone and moderate-brown to yellowish-orange sandstone. Here the Pajarito is sharply overlain by bioturbated quartzarenite, the Romeroville Sandstone of Kues and Lucas (1987), mapped in this area as Dakota Sandstone by Wanek (1962).

Lower Cretaceous stratigraphic nomenclature in east-central New Mexico

Two sets of nomenclature, one formal and the other informal, have generally been applied to Lower Cretaceous strata in east-central New Mexico (Fig. 5). The formal nomenclature is based on outcrops in Quay County, whereas the informal nomenclature has its origin to the west, in San Miguel County. Although there is a one-to-one correspondence between informal and formal stratigraphic names, the dual nomenclatures have led to some confusion (see Stone, 1984; Fig. 5), and for this reason we advocate abandonment of the informal nomenclature.

TABLE 5—Reference section of Pajarito Formation. Measured in the NW¼ NW¼ sec. 17 and the SW¼SW¼ sec. 8, T18N, R27E, Harding County.

Unit	Lithology	Thickness (m)
	Romeroville Sandstone	
5	Sandstone, light-brown (5 YR 5/6), weathers to dark yellowish brown (10 YR 4/2), quartzose, noncalcareous, medium-grained, subangular to angular, moderately well sorted, massive (intensively bioturbated); cement is iron rich and some grains are iron stained.	6.1+
	Pajarito Formation	
4	Sandy siltstone, medium-gray (N 5), weathers to light gray (N7); sand fraction is quartzose and very fine grained; silt fraction is noncalcareous and slightly carbonaceous.	9.8
3	Sandstone, very light gray (N 8), weathers to moderate brown (5 YR 4/4), indurated, very fine grained, subangular, moderately well to well sorted, massive (intensively bioturbated), quartzose, noncalcareous; some limonite stains.	0.2
2	Muddy sandstone, yellowish-gray (5 Y 8/1), weathers to dark yellowish orange (10 YR 6/6); sand fraction is quartzose, noncalcareous, very fine grained, subangular and well sorted; clay fraction is moderate brown (5 YR 4/4), fissile and hematitic.	0.5
	Total	**10.5**
	Mesa Rica Sandstone	
1	Sandstone, very pale orange (10 YR 8/2), weathers to light brown (5 YR 6/4) and pale brown (5 YR 5/2), quartzose, fine-grained, angular, moderately well sorted, moderately friable, very slightly calcareous; some kaolinitic cement.	not measured

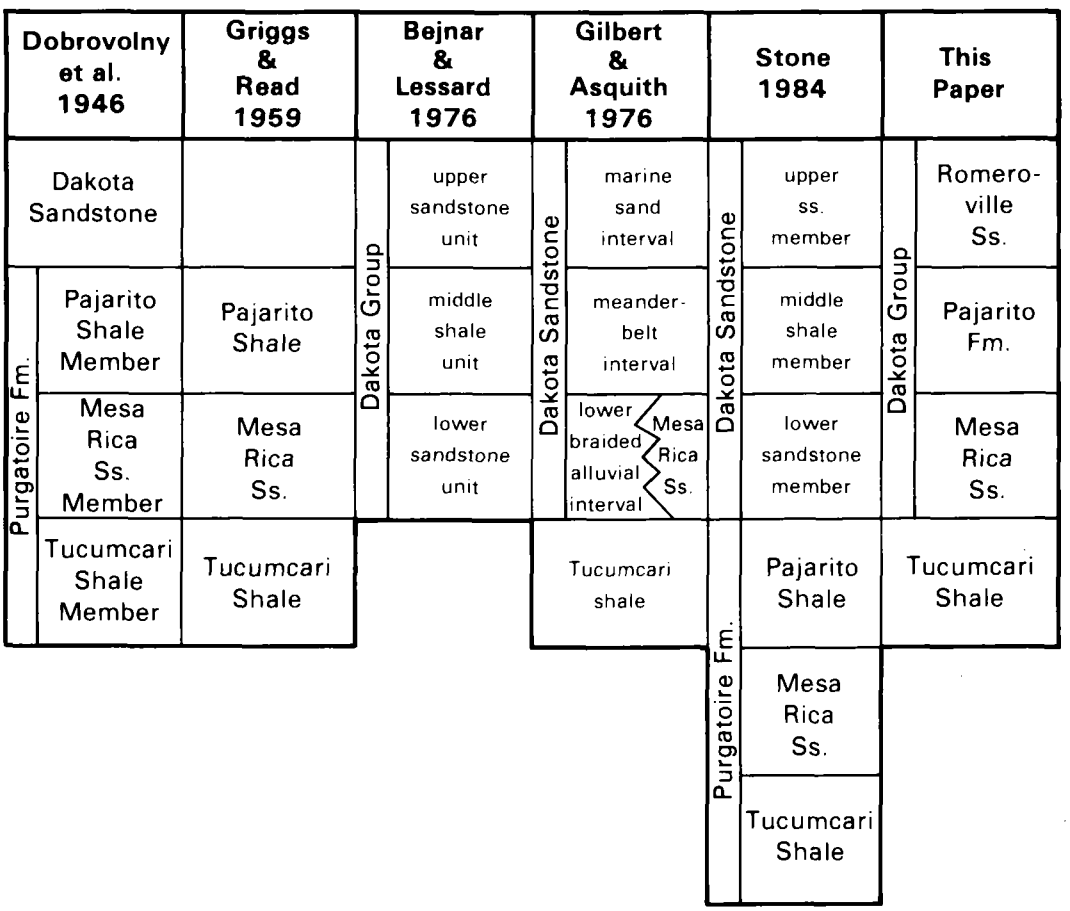

FIGURE 5—Comparison of stratigraphic nomenclature of Lower Cretaceous rocks in east-central New Mexico used by some earlier workers with nomenclature advocated in this paper.

Both nomenclatures recognize the Tucumcari Shale as the oldest marine Cretaceous unit present in east-central New Mexico. Sandstone immediately below the Tucumcari in parts of east-central New Mexico earlier identified as a Cheyenne (Trauger, 1972) or a Lytle equivalent (Scott, 1970) have been shown to be part of the Morrison Formation (Payne et al., 1986; Holbrook et al., 1987) or pertain to the thin, basal Campana Sandstone Bed of the Tucumcari Shale as defined by Holbrook et al. (1987). Above the Tucumcari, the formal term Mesa Rica Sandstone has been used interchangeably with the informal terms "lower sandstone unit (member)" or "lower braided alluvial interval." Because it is clear that a single stratigraphic unit is represented (e.g., Mateer, 1985, 1987), we propose that the name Mesa Rica Sandstone be used throughout this region in place of the informal names. For the same reason, we advocate use of Pajarito Formation throughout east-central New Mexico for the overlying unit instead of the informal terms "middle shale unit (member)" or "meander-belt interval." The term Romeroville Sandstone (Kues and Lucas, 1987) is advocated by us as a formal term equivalent to earlier usages of "upper sandstone unit (member)" or "marine sand interval."

We favor abandonment of the term Purgatoire in east-central New Mexico for the same reasons as Griggs and Read (1959) and Kues and Lucas (1987). We use the term Dakota as a group to encompass the Mesa Rica, Pajarito and Romeroville formations, contrary to some earlier uses of the term Dakota in this region. Thus, at group rank, the Dakota encompasses both Lower and Upper Cretaceous rocks. Mateer's (1987) use of the terms Dakota and Muddy are rejected by us for the reasons stated by Kues and Lucas (1987).

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NMGS Spring Meeting
Call for papers

The New Mexico Geological Society will hold its annual spring meeting in early April 1989 in Macey Center at the New Mexico Institute of Mining and Technology, Socorro, New Mexico. Papers are being solicited for this annual meeting, which promotes the dissemination of results of recent research on the geology of New Mexico. Four topics are to be considered: economic geology (metals, oil and gas, coal, industrial minerals, uranium), hydrology and environmental geology, sedimentary geology, and volcanic and structural geology. Only material directly concerning the geology of New Mexico will be considered. Abstracts must be received by February 15, 1989. Please send GSA-style abstracts, 250-word limit, to general chairman Jim Barker, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801, (505) 835–5114. Authors should state which of the four topics is most appropriate for their paper. An award will be presented for the student paper judged outstanding; for more information on this voluntary competition, contact the general chairman.