



Synopsis of Tucumcari Shale, Mesa Rica Sandstone, and Pajarito Shale paleontology, Cretaceous of east-central New Mexico

Barry S. Kues, Spencer G. Lucas, Kenneth K. Kietzke, and Niall J. Mateer
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SYNOPSIS OF TUCUMCARI SHALE, MESA RICA SANDSTONE AND PAJARITO SHALE PALEONTOLOGY, CRETACEOUS OF EAST-CENTRAL NEW MEXICO

BARRY S. KUES¹, SPENCER G. LUCAS¹, KENNETH KIETZKE¹ and NIAL J. MATEER²

¹Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131; ²Department of Geology, McMurry College, Abilene, Texas 79697

INTRODUCTION

Early Cretaceous fossils from east-central New Mexico were among the first to be collected (by members of the 1849 Marcy and 1853 Whipple expeditions) and studied scientifically (Marcou, 1855b, 1858; Hall, 1856) from New Mexico (Kues, 1985a). Despite this early start, and a bitter 40-year controversy arising from Marcou's belief in their Jurassic age (Kues, 1985b), the Early Cretaceous biotas of east-central New Mexico are still incompletely known. Most of the taxa reported from this interval are from the Tucumcari Shale, which is securely placed in the upper Albian on the basis of biostratigraphic correlation with units in Texas and Kansas (Scott, 1970a; Brand and Mattox, 1972; Scott and Taylor, 1977). The overlying Mesa Rica Sandstone and Pajarito Shale are sparsely fossiliferous, and their exact ages have not been established—they may be late Albian and/or early Cenomanian (late Early or early Late Cretaceous) in age.

Since the time when the Early Cretaceous age of the Tucumcari Shale fauna was firmly established (Cummins, 1892; Hill, 1895), few studies of this fauna have been published aside from citations of taxonomic names (e.g., Darton, 1928; Dobrovolsky et al., 1946; Brand and Mattox, 1972). However, Stanton (1947) described several molluscs from the Tucumcari, including two new species of gastropods, and Scott (1974) described a number of marine paleocommunities in the Tucumcari Shale and interpreted the paleoecology of the fauna. The macrofauna has not been systematically described, although many of the species that occur in the Tucumcari Shale have been described from equivalent units in Kansas (Scott, 1970b). A profuse microfauna (foraminiferans and ostracodes) is known to be present in the Tucumcari (Brooks, 1959; Kietzke, 1985).

In this paper, we summarize the nature of the Tucumcari, Mesa Rica and Pajarito biotas, illustrate some characteristic invertebrate species and provide an annotated catalog to the taxa reported from these formations. Two of us (BSK, KK) have relocated the site at Pyramid Mountain where, in 1853, Jules Marcou made the first paleontological collections from the unit now called the Tucumcari Shale (Kues, 1985b; Kues and Kietzke, 1985), and illustrations of fossils from this important but long-forgotten locality, including topotypes of *Texigryphaea tucumcarii*, are included. Most illustrated specimens are deposited in the University of New Mexico Department of Geology paleontology collection and bear UNM catalog numbers.

STRATIGRAPHIC CONTEXT

The pre-Dakota Cretaceous strata of east-central New Mexico are assigned, in ascending order, to three lithostratigraphic units: Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale (Fig. 1). These three units formerly were recognized as members of the Purgatoire Formation (Dobrovolsky et al., 1946). However, current usage rejects extension of the term Purgatoire (Stose, 1912) from southeastern Colorado into northeastern and east-central New Mexico (Griggs and Read, 1959).

The unit presently known as the Tucumcari Shale was first studied by Jules Marcou, who referred to it as a 30-ft-thick clay of slightly grayish-blue color and subchistose structure—Bed E of his Pyramid Mountain section (Marcou, 1858a, p. 18). Later, Marcou (1889b, p. 365) used the term "Tucumcari beds" for the entire post-Triassic part of that section (his Beds B–G), and Cummins (1892, p. 201) utilized the same term for an equivalent part of the section at Tucumcari Mountain but excluded 20 ft of Tertiary limestone at the very top of the section. The "Tucumcari beds" of Marcou and Cummins included a

lith.	thickness	Rock-Strat. Unit	Stage/Age	P.
	20 m	PAJARITO SHALE	Cenomanian	Cretaceous
	43 m	MESA RICA SANDSTONE	— ? —	
	24 m	TUCUMCARI SHALE	Albian	
	-	MORRISON FRMN.	Tithonian	1

FIGURE 1. Generalized stratigraphic section of the Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale in east-central New Mexico.

thick sequence of Jurassic sandstones (now the Exeter and Morrison Formations), a thin fossiliferous shale (the present Tucumcari Shale) and an overlying massive sandstone unit (Mesa Rica Sandstone). Cragin (1895, p. 382) applied the term "Tucumcari shales" to "the zone characterized in part by . . . *Gryphaea tucumcarii*," but provided no additional stratigraphic information and was uncertain of the extent of the unit because the stratigraphic ranges of the fossils in the Tucumcari area were too poorly known. Cragin recognized the "Tucumcari shales" in Texas and Kansas as a subunit of the Kiowa shales. His usage of the term seems to have been more as a biostratigraphic interval than as a lithostratigraphic unit.

The present concept of the Tucumcari Shale essentially derives from the work of Dobrovolsky et al. (1946), who described it as "a unit of gray shale and buff calcareous sandstone that contains nodules of argillaceous limestone, and has a thin basal sandstone." As so conceived, the Tucumcari Shale disconformably overlies the Morrison Formation; this disconformity apparently represents about 30 million years (Tithonian–late Albian: time-scale of Harland et al., 1982). The Tucumcari Shale is overlain either conformably or disconformably by the Mesa Rica Sandstone; the precise placement of the boundary is not agreed upon (see discussion below). The maximum reported thickness of the Tucumcari Shale is about 94 ft (28 m) (Brand, 1953), but this may include some basal Mesa Rica sandstone units. Scott (1970a) reported the thickness to range from 0 to 60 ft (0 to 18 m).

Dobrovolsky et al. (1946) named the "Mesa Rica Sandstone member of the Purgatoire formation" for "a white or brownish-buff, cross-bedded, medium- or coarse-grained sandstone that is massive or cliff-forming." They also noted that "locally lenses of quartz-pebble conglomerate occur at the base" of the Mesa Rica. The Mesa Rica attains a maximum thickness of 43 m in east-central New Mexico (Gage and Asquith, 1977). Although Dobrovolsky et al. (1946) did not designate a type section for their "Mesa Rica Sandstone member," the name was

taken from Mesa Rica in northwestern Quay and southeastern San Miguel Counties. Apparently its type area is near the southeastern flank of the mesa in the Hondo Canyon–Pajarito Creek area (i.e., near measured stratigraphic section 1 of Dobrovolsky et al., which is in the SW $\frac{1}{4}$, sec. 9, T11N, R29E).

Griggs and Read (1959) raised the term Mesa Rica to formational rank, a conclusion accepted by all subsequent workers. However, the precise boundaries of the Mesa Rica Sandstone and its relationship to the Dakota Sandstone have not yet been agreed upon. Thus, approximately 3 m of fine-grained sandstone that contain an invertebrate macrofauna similar to that occurring in the Tucumcari Shale have been included in the basal Mesa Rica Sandstone (Griggs and Read, 1959) or placed in the uppermost Tucumcari Shale (Scott, 1970a). Also, some workers have argued that the Mesa Rica is equivalent to all or part of the Dakota Sandstone (e.g., Scott, 1970a; Gage and Asquith, 1977), whereas others have considered the Mesa Rica to be a separate unit stratigraphically lower, and hence older, than the Dakota (e.g., Dobrovolsky et al., 1946; Wanek, 1962). Clearly, more detailed stratigraphic and paleontologic study of the Mesa Rica is needed to resolve these problems.

The "Pajarito shale member of the Purgatoire formation" of Dobrovolsky et al. (1946) was described as "soft brown sandstone alternating with gray shale that contains *Ostrea* [now *Lopha*] *quadriplicata*." The name was taken from Pajarito Creek in northwestern Quay County, and

we consider the type area of the Pajarito Shale to be essentially the same as that of the Mesa Rica Sandstone. The Pajarito Shale attains a maximum thickness of 20 m in east-central New Mexico (Dobrovolsky et al., 1946; Gage and Asquith, 1977). It is overlain by the Graneros Shale in the Bonita fault zone south of San Jon (T8N, R32E) and conformably overlies the Mesa Rica Sandstone (Dobrovolsky et al., 1946; Scott, 1970a). Virtually no stratigraphic or paleontologic studies of the Pajarito have been undertaken.

LOCALITIES

We have identified more than 50 fossil localities in the Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale of east-central New Mexico (Fig. 2; Appendix). Most of these localities are in the Tucumcari Shale, and most have previously been reported in the literature. Our preliminary field efforts have identified several new localities and have resulted in the relocation of some previously reported localities (Fig. 3).

PYRAMID MOUNTAIN AND *GRYPHAEA TUCUMCARI*

Jules Marcou visited Pyramid Mountain on 22 September 1853 and collected more than one hundred specimens of a large gryphaeid, together with a few examples of a large oyster he called *Ostrea marshii*, from a shale bed near the summit. The similarity of these fossils to species he knew from the Jurassic of Europe led him to consider the

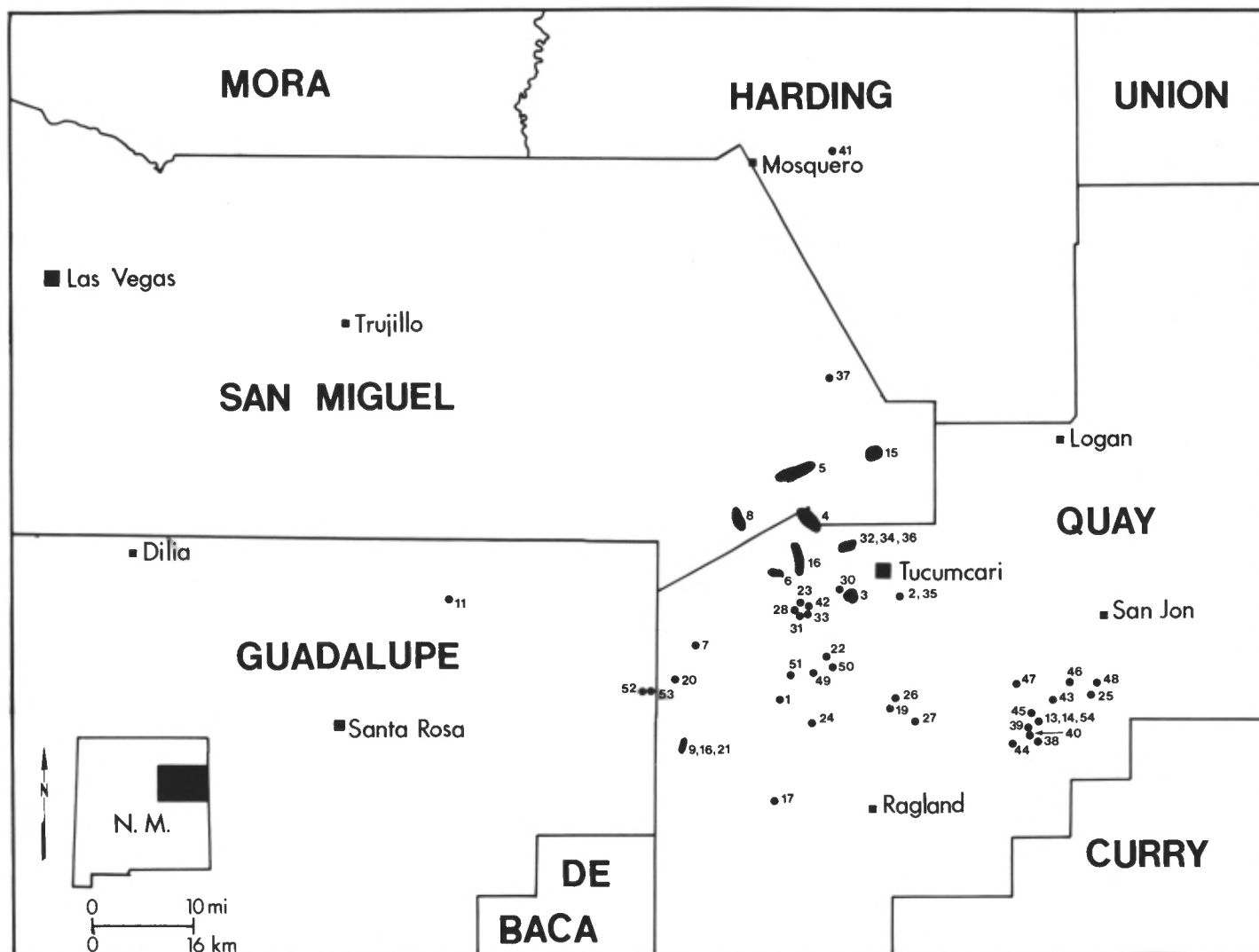


FIGURE 2. Localities from which fossils have been reported in the Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale in east-central New Mexico. The locality numbers are those listed in the appendix. Not shown on this map are localities 10, 12, 29, 55, 56 and 57.

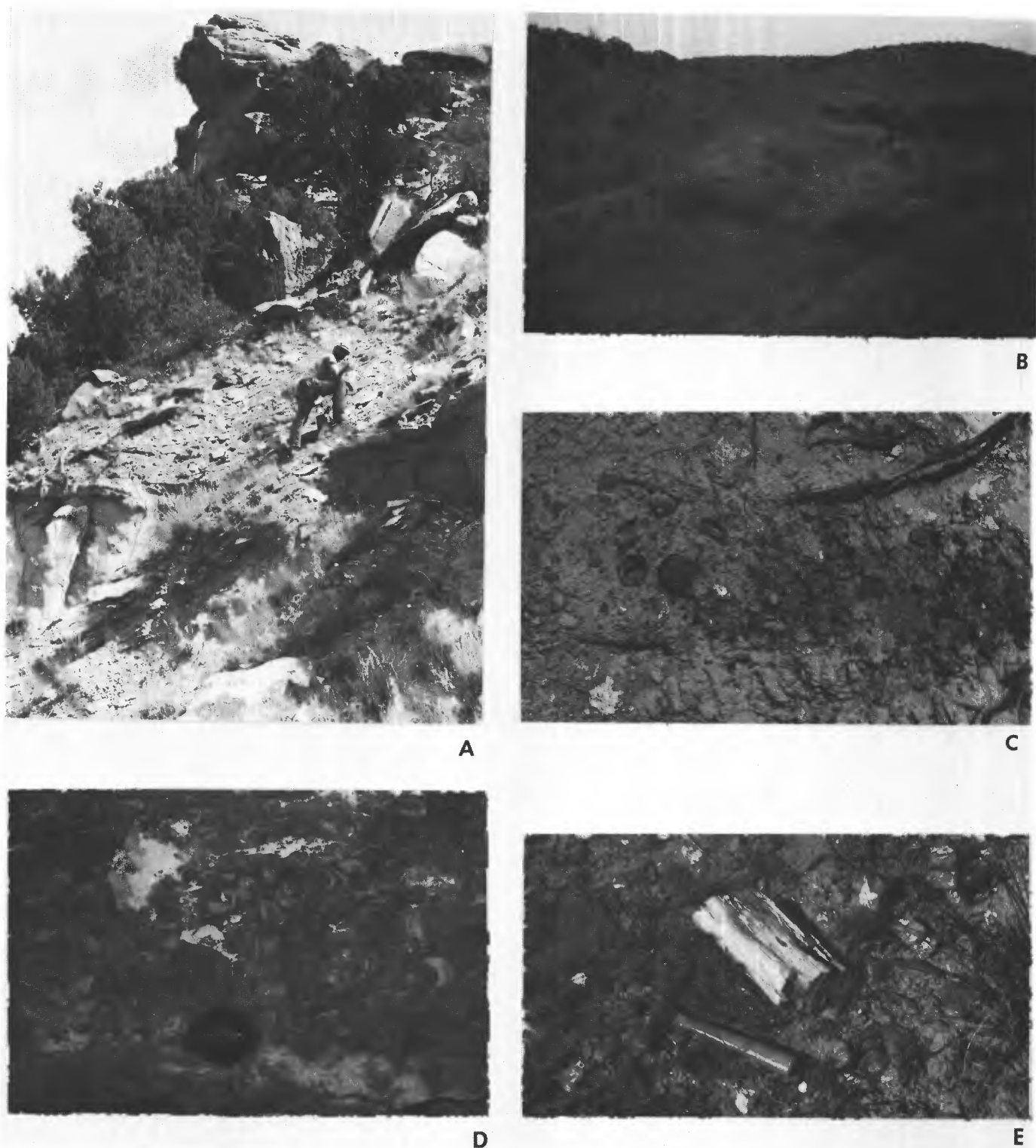


FIGURE 3. Tucumcari Shale-Mesa Rica localities. A, Tucumcari Shale (slope with man) overlain by cliff-forming Mesa Rica Sandstone near summit of Pyramid Mountain (locality 1), probably the place where Marcou made the first collections of fossils from the Tucumcari Shale in 1853; B, Tucumcari Shale near I-40, about 8 mi (13 km) west of Tucumcari (localities 23, 28, 31, 33, 42); C, typical occurrence of large numbers of *Texigryphaea* valves eroded from Tucumcari Shale (locality 42); D, *Texigryphaea* biostrome in roadcut just west of Ima (locality 18); E, petrified wood eroded from Mesa Rica Sandstone, Luciano Mesa (locality 52).

entire stratigraphic sequence above the underlying Triassic red beds to be of Jurassic age. Marcou originally described the common gryphaeid at Pyramid Mountain, a form with a broadly flaring posterior flange and well-developed sulcus, as *Gryphaea dilatata*, a European Jurassic species (Marcou, 1855b, p. 880, pl. 21, figs. 1–2). A large, relatively elongate variety (described by Marcou, 1858a, as “a very long full-grown specimen”) with a gentle posterior expansion was named *G. dilatata* var. *tucumcarii* (Marcou, 1855b, p. 880, pl. 21, fig. 3). Later, Marcou (1858a, p. 43, pl. 4, figs. 1–3, and subsequent papers) assigned all of the specimens from Pyramid Mountain to *G. dilatata* var. *tucumcarii*, which he often also called *G. tucumcarii*. A copy of Marcou’s illustrations of these taxa (Marcou, 1858a, pl. 4) is included as Figure 4. The left valve originally designated *G. dilatata* var. *tucumcarii* by Marcou (British Museum No. LL 1493, formerly No. 12676) was photographed by Adkins (1927, pl. 4, fig. 1; 1928, pl. 6, fig. 1), who reported it to be the holotype of *G. tucumcarii*. Fay (1975, figs. 23–24) also published photographs of this specimen, including the first view of its external surface. The site where Marcou made his collection has been confused with Tucumcari Mountain by several workers (e.g., Cragin, 1895; Bullard, 1928; Fay, 1975), but Pyramid Mountain is actually about 15 mi (24 km) southwest of Tucumcari Mountain.

Immediately after Marcou published his first description of the Pyramid Mountain bivalves, American paleontologists disputed both his identifications and his Jurassic age assignment. The oyster that Marcou

had called *Ostrea marshii* was referred to *Ostrea* [now *Lopha*] *subovata* Shumard. Marcou’s *G. dilatata* and *G. dilatata* var. *tucumcarii* were said to be representatives of the widespread *G. pitcheri*, which was later placed into synonymy with *G. corrugata* (Hill and Vaughan, 1898) but reinstated as a valid species by Fay (1975), who considered *G. corrugata* a *nomen nudum*. Both *L. subovata* and the gryphaeid were stated to be of Cretaceous rather than Jurassic age (see Kues, 1985b, for a full discussion of this controversy). Additional specimens from Pyramid Mountain described and illustrated by Hall (1856, pp. 99–100, pl. 1, figs. 1–6) as *G. pitcheri* appear to be moderately wide but without the flaring posterior flange and pronounced sulcus that characterized some of Marcou’s specimens (e.g., his pl. 4, fig. 1).

With the discovery of additional fossils from the “Tucumcari beds” in the late 1880’s and 1890’s, the Early Cretaceous age of the fauna was established and faunal lists of the time (e.g., Cummins, 1892; Hill, 1895) included both *G. pitcheri* and *G. tucumcarii*. These authors thus supported Marcou’s long-standing contention that significant morphological differences existed between the two species. During the 1890’s *G. tucumcarii* was also reported from localities in Kansas and Texas (Dumble and Cummins, 1893; Hill, 1895; Cragin, 1895; Vaughan, 1897). However, because descriptions of these species were not given, it is difficult to know whether various authors were applying the name to the same gryphaeid. For example, Cummins (1892) implied that the *G. tucumcarii* in the Tucumcari area was the broad, posteriorly dilate form originally called *G. dilatata* by Marcou, whereas Dumble and Cummins (1893) specifically referred to the elongate, relatively narrow specimen illustrated by Marcou (1858a, pl. 4, fig. 3) as the basis for their concept of *G. tucumcarii* in western Texas. Cragin (1895, p. 38) remarked upon the intergradation of *G. tucumcarii* with a third species, *G. roemeri*, in the Kiowa shales of Kansas.

Hill and Vaughan (1898) monographed the North American Lower Cretaceous gryphaeids and considered *G. tucumcarii* to be only a variety of *G. corrugata* Say. Most subsequent authors (e.g., Adkins, 1927, 1928; Stenzel, 1959; Scott, 1970a) have continued to regard *Gryphaea* (now *Texigryphaea*) *tucumcarii* as a valid species. Hill and Vaughan failed to adequately differentiate their *G. corrugata* var. *tucumcarii* from typical representatives of the species, stating only (p. 56) that the variety was a large form with features as illustrated by Marcou. Because the type specimen of *G. corrugata* is lost (Hill and Vaughan, 1898, p. 34; Fay, 1975, p. 46), and was neither adequately described nor figured, Fay’s suppression of the name is justified. The type of *G. pitcheri* Morton is available and has been illustrated by several authors (Hill and Vaughan, 1898, pl. 6, figs. 5–7; Stanton, 1947, pl. 10, figs. 4–5; Fay, 1975, figs. 19–20). Thus, *G. pitcheri* can be compared directly to specimens assigned to *G. tucumcarii* by Marcou and others. Before doing so, however, some comments should be made concerning the concept of *G. corrugata* utilized by various authors in the period from 1898 to 1975.

Hill and Vaughan’s (1898) concept of *G. corrugata* (pp. 54–57) was apparently based on Say’s description of the species, on numerous specimens that probably belong to *G. pitcheri*, and on several putative varieties, including *G. corrugata* var. *tucumcarii*. *Gryphaea corrugata* included gryphaeids with a lower valve significantly higher than wide, a distinct sulcus and a fairly prominent but highly variable posterior flange. Large, elongately oval forms with a reduced posterior flange and sulcus were also assigned to *G. corrugata* sensu stricto (e.g., Hill and Vaughan, 1898, pl. 12, figs. 1–2; Stanton, 1947, pl. 10, figs. 3, 6). These are very similar to the large, narrow specimen of *G. tucumcarii* illustrated by Marcou (1855b, pl. 21, fig. 3; 1858a, pl. 4, fig. 3) and are far more similar to that species than to typical specimens of *G. pitcheri*.

In contrast, specimens with a broad lower valve (width nearly equal to height), a relatively low and rounded posterior flange and a poorly to moderately well-developed sulcus have generally been referred to *G. tucumcarii* or *G. corrugata tucumcarii*. Illustrations of this species or variety (e.g., Hill and Vaughan, 1898, pl. 14, figs. 1–2, reproduced in this paper as Fig. 5; Stanton, 1947, pl. 14, fig. 4 and pl. 15, figs. 13–14; Stenzel, 1959, figs. 4, 11) show these characteristics clearly.

The type specimen of *Gryphaea pitcheri* Morton, as illustrated by

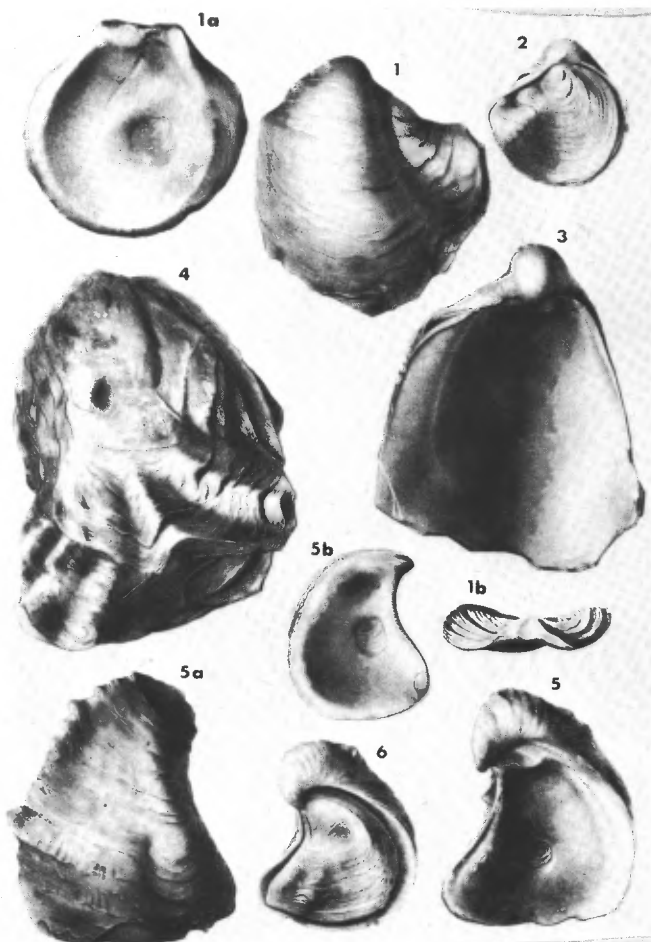


FIGURE 4. Copy of Marcou’s (1858a) plate 4, showing specimens designated as *Gryphaea dilatata* (figs. 1–2), *G. dilatata* var. *tucumcarii* (fig. 3) and *Ostrea marshii* (fig. 4) from Pyramid Mountain. These specimens were also illustrated three years earlier (Marcou, 1855b, pl. 21). Figures 5 and 6 are of specimens from Oklahoma called *G. pitcheri* by Marcou but now known as *Texigryphaea navia*. The specimens were originally illustrated at their original sizes, but the plate has been reduced here by about 50% and the figure numbers have been darkened.

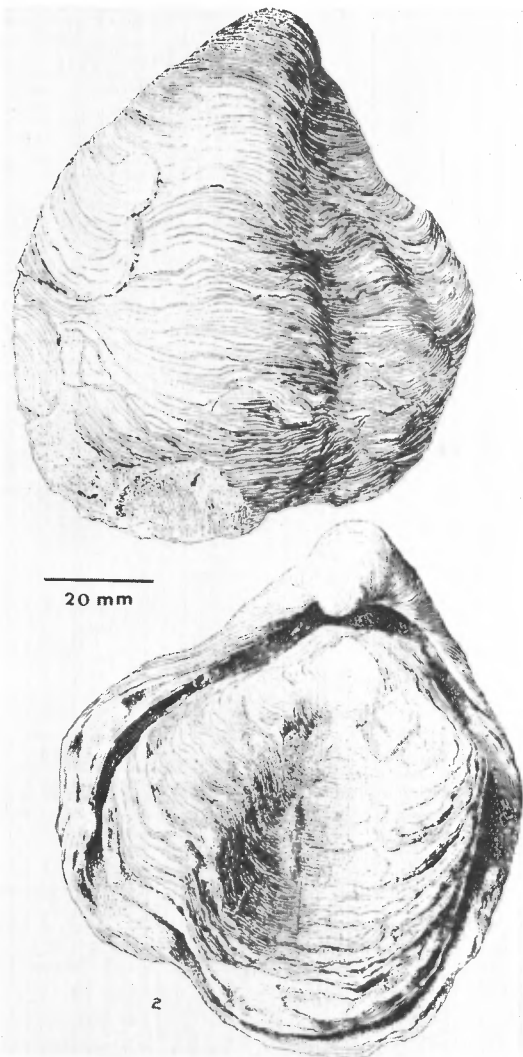


FIGURE 5. Copy of Hill and Vaughan's (1898) plate 14, figures 1–2, showing a typical large specimen of *Texigryphaea tucumcarii* from Tucumcari Mountain, collected by A. Hyatt in the late 1880's.

Hill and Vaughan (1898), Stanton (1947) and Fay (1975), has a relatively elongate left valve with a pronounced, curved posterior lobe that imparts a concave profile to the postero-dorsal margin as it descends rather abruptly from the beak area. A moderately strong sulcus is also present. The specimens from Pyramid Mountain illustrated by Hall (1856), and the other typical specimens of *Texigryphaea tucumcarii* mentioned above, though clearly distinct, bear a closer resemblance to *T. pitcheri* than do Marcou's "very long" specimens (Marcou, 1858a, pl. 4, fig. 3). Marcou's figure of a left valve of what he called *G. dilatata* (Marcou, 1858a, pl. 4, fig. 1), with its unusually strong sulcus, extended posterior lobe, and concave postero-dorsal margin, represents an extreme variant that approaches *T. pitcheri* closely in several respects.

Given the variability of the Tucumcari specimens, the resemblance of some of them to forms from other areas referred to *G. pitcheri* and the fact that Marcou's figured specimens were in Europe and unavailable for examination, it is not surprising that the Tucumcari gryphaeids were considered by most paleontologists of the time to be representatives of *G. pitcheri*. Gabb (1862), working with Marcou's illustrations of *G. tucumcarii* and specimens of *G. pitcheri* from Oklahoma, claimed that there is an unbroken series of gradations from one species to the other and maintained that they were synonymous. Even today, no detailed comparative studies of the two species, utilizing modern concepts of ecophenotypic and geographic variation and modern methods of sta-

tistical analysis, have been done to determine the degree of intergradation between these two species. *Texigryphaea corrugata* (= *T. pitcheri*) has also been reported to intergrade to some extent with two other species—*T. navia* and *T. belviderensis* (Stanton, 1947; Scott, 1970b).

In our examination of the Tucumcari Shale fauna at Pyramid Mountain we found Marcou's observations to be accurate. He reported (1858a, pp. 18–19) a zone of dense gryphaeids from the base of a grayish-blue clay (his Bed E, the modern Tucumcari Shale) near the top of the peak. This zone was readily located in an exposure of Tucumcari Shale along the northwest side of Pyramid Mountain (Fig. 3A), and, because most of the Tucumcari is covered by float from the Mesa Rica Sandstone, we believe this relatively exposed and easily accessible locality to be the place where Marcou made his collections in 1853 (see Kues and Kietzke, 1985). Gryphaeids greatly dominate this assemblage, with only a few specimens of *Lopha subovata* (Marcou's *Ostrea marshii*) and *Lopha quadriplicata* having been observed.

Our collections of *Texigryphaea* from this locality include many specimens with a broad left valve that is nearly round in marginal profile, possesses a moderately expanded posterior flange, and has a sulcus that is typically shallow but in some specimens may be pronounced (Figs. 6, 7). This form includes some of the specimens of *G. tucumcarii* illustrated by Marcou (1855b, pl. 21, figs. 1a–2; 1858a, pl. 4, figs. 1a–2) and those described as *G. pitcheri* by Hall (1856, pp. 99–100, pl. 1, figs. 1–6) from the Pyramid Mountain locality. We also collected a small number of large, elongate left valves with a subdued posterior flange (Figs. 6A, B) similar to Marcou's narrow specimen (Marcou, 1855b, pl. 21, fig. 3; 1858a, pl. 4, fig. 3), which was the basis of the species *G. tucumcarii*. We observed a considerable but nearly continuous range of variation from elongate specimens to broad ones with a moderately extended posterior flange (Figs. 6, 7). The increasing development of the flange is reflected in an increasing asymmetry of the postero-dorsal and antero-dorsal valve margins. In the elongate forms both margins are gently and evenly convex and descend from the beak area at similar, relatively high angles, whereas the postero-dorsal margin of strongly flanged specimens may be concave and extend posteriorly from the beak area at a low angle compared to the antero-dorsal margin. Some highly flanged forms also have a prominent, curved sulcus (e.g., the left valve illustrated by Marcou, 1858a, pl. 4, fig. 1, as *G. dilatata*, and a few specimens in our collections: see Fig. 6H, I) and converge in many respects with *T. pitcheri*. The smaller, relatively flat right valves reflect the shape of the left valve margins and range from approximately circular to strongly flanged (Fig. 7C–F).

We have made additional collections of *Texigryphaea* from the Tucumcari Shale at several other localities in Quay and Guadalupe Counties, and in general most of the specimens fall within the range of variation mentioned above for the Pyramid Mountain specimens. A few specimens represent variants not observed at Pyramid Mountain. At Locality 28, west of Tucumcari, a few elongately oval individuals have an unusually thick, massive left valve and only a hint of an external posterior sulcus (Fig. 8A, B). These are possibly ecological variants of the elongate form of *T. tucumcarii*. Some specimens from Locality 53, near Bull Canyon, have beaks that are twisted posteriorly to a far greater degree than is typical of *T. tucumcarii*, and display a relatively thin but strongly extended posterior flange (Fig. 8C, D). These are similar in the lateral curvature of their beaks to forms recognized elsewhere as *T. navia*, but that species has a more massive, lamellate shell. Our studies of Tucumcari Shale *texigryphaeas* are preliminary, and we do not as yet have sufficient data to evaluate the morphological variability present in these assemblages or to draw firm taxonomic conclusions regarding the relationships of *T. tucumcarii* and *T. pitcheri*. A comprehensive study of the Albian gryphaeids from the southern Western Interior would be a worthwhile endeavor.

THE TUCUMCARI SHALE FAUNA

The Tucumcari Shale contains a moderately diverse Albian marine invertebrate fauna consisting of more than 65 reasonably reliably reported species (see below), including numerous foraminiferans, ostracodes and palynomorphs. The megafauna as a whole is dominated by bivalves, which comprise about 60% of all reported species; most of

the remaining species are gastropods and ammonoids. Photos of characteristic Tucumcari Shale invertebrates appear in Figures 6 through 9.

Scott (1974) studied the distribution and paleoecology of the Tucumcari Shale fauna preserved at several localities in the eastern part of the outcrop area, particularly near San Jon. He reported that Tucumcari sedimentation occurred in environments ranging from offshore open sea or open-bay muds to nearshore and upper-shoreface sands. Five associations or communities of benthic organisms were recognized in the Tucumcari Shale and equivalent units in Kansas, Oklahoma and southeastern Colorado: open bay *Nucula-Nuculana*, lower shoreface *Corbula-Breviarca*, lower shoreface *Texigryphaea-Lopha* biostrome, middle shoreface *Scabrotrigonia-Turritella* and upper shoreface *Arenicolites* communities. Scott (1975) also examined molluscan diversity gradients in Washita-age marine environments in the southern Western Interior and found that the diversity of all molluscs (bivalves, gastropods, cephalopods) in east-central New Mexico was low compared to north-central and western Texas and Kansas. Scott interpreted these diversity differences as being due to reduced habitat variation and an increased instability or unpredictability of limiting factors such as salinity and resource supplies in low-diversity areas like east-central New Mexico. By implication, the communities of the Tucumcari Shale were structurally simple and dominated by infaunal suspension feeders; indeed, the ratio of infaunal to epifaunal species reported by Scott (1975, fig. 3D) for New Mexico Washita-age communities is among the highest in the southern Western Interior. Scott also noted that the Washita Sea transgressed from Texas north and west into the Western Interior, so that areas such as east-central New Mexico and southeast Colorado were inundated for about half the time that Texas was submerged.

During our preliminary field studies of the Tucumcari Shale we observed that the *Texigryphaea-Lopha* and *Scabrotrigonia-Turritella* associations were the most conspicuous at the localities we examined. The *Texigryphaea-Lopha* association, for example at the base of the Tucumcari Shale at Pyramid Mountain, is locally characterized by dense accumulations of large (up to 100 mm in height), usually disarticulated valves of *Texigryphaea*, with few other associated taxa. At locality 50, south of Mesa Quemado, several small solitary conical corals were collected among more numerous specimens of *Scabrotrigonia* and *Turritella*. Such corals (*Turbinolia* [now *Desmophyllum*] *texana*) appear in some of the early faunal lists of the Tucumcari Shale, but were not reported by Scott (1970a, 1974) or other recent workers, although Scott (written comm. 1985) did find the small button-shaped coral *Platycyathus* at the San Jon locality. A large pteriod bivalve (Fig. 9A) was also recovered from Locality 50. This specimen resembles *Pteria salinensis* White, but appears to be less inflated and have a smaller anterior auricle than that species. *Pteria salinensis* is known in equivalent units in Kansas and Texas, but no species of *Pteria* have been reported previously from the Tucumcari Shale.

The valves of *Texigryphaea* and *Lopha* were utilized as a hard substrate by a variety of epizoans, particularly small individuals of those genera. Twisted masses of serpulid-worm tubes (*Serpula cragini* Twenhofel and a second species with smaller tubes about 0.5 to 0.8 mm in diameter) are moderately common; small membraniporid-bryozoan zoaria and attached foraminiferans are relatively rare. Several types of borings are also present in the valves of *Texigryphaea*. Most abundant are small (0.7 to 1.0 mm in diameter), circular, shallow pits that are generally arrayed along the ventral and posterior margins of left valves. Some valves were perforated by these borings to the extent that the borings evidently were responsible for the pre-burial disintegration of the valve margins. These borings (e.g., Fig. 6B), probably from clionid sponges, are seldom present on the internal surfaces of valves. Less common are the elongate, slit-shaped borings of acrothoracic barnacles. These are up to about 2 mm long, with a width ranging from one-fourth to

one-half the length, and some curve sharply or expand abruptly at one end. The relatively large (10 mm), oval, obliquely oriented, shallow borings of the bivalve *Botula* were observed in a few valves. Tiny, stellate-filamentous clusters excavated just below the surface of some valves indicate the presence of endolithic algae or fungi.

MESA RICA SANDSTONE AND PAJARITO SHALE BIOTAS

Few fossils have been reported from the Mesa Rica Sandstone and Pajarito Shale. Gage and Asquith (1977) interpreted the Mesa Rica as a lobate sand body representing lower shoreface to distributary-channel estuarine environments. Trace fossils such as *Rhizocorallum* and *Ophiomorpha* are common locally, together with a few bivalves, shark teeth and silicified wood. Griggs and Read (1959) stated that the Tucumcari Shale marine fauna extends through the lower 10 ft of the Mesa Rica, but Scott (1970a) included this fossiliferous sandy interval in the Tucumcari Shale. One of us (NJM) examined a small suite of invertebrates from the Mesa Rica Sandstone in the collections of the U.S. Geological Survey in Denver. These specimens came from Localities 43 to 48 in the Apache Canyon area east of Mesa Redonda, possibly from the lower sandstone; a few of the better preserved specimens are illustrated here (Figs. 8, 9). One incomplete specimen of the ammonoid *Mortoniceras equidistans* (Fig. 9I) was collected from the lower Mesa Rica near Bull Canyon (Locality 52). Cummins (1892) reported an angiosperm-plant leaf, which he called *Sterculia drakei*, from the Mesa Rica, but Hill (1895) claimed that it came from below the marine invertebrate horizons of the Tucumcari Shale (see list of taxa below).

The only invertebrate fossil reported from the Pajarito Shale is *Lopha quadriplicata*, from an unspecified locality in northwestern Quay County (Dobrovolsky et al., 1946). The U.S. Geological Survey collection contains several small fossiliferous shale slabs labeled "*Ostrea quadriplicata*, top of Pajarito sh., sec. 34, T8N, R32E [our Locality 57], Quay Co., N. Mex." (Fig. 10). These are probably the specimens reported by Dobrovolsky et al. (1946). Judging from the shell fragments preserved with *L. quadriplicata*, it is likely that other taxa will eventually be reported from the Pajarito. Plant and wood fragments were also observed in the Pajarito by Gage and Asquith (1977).

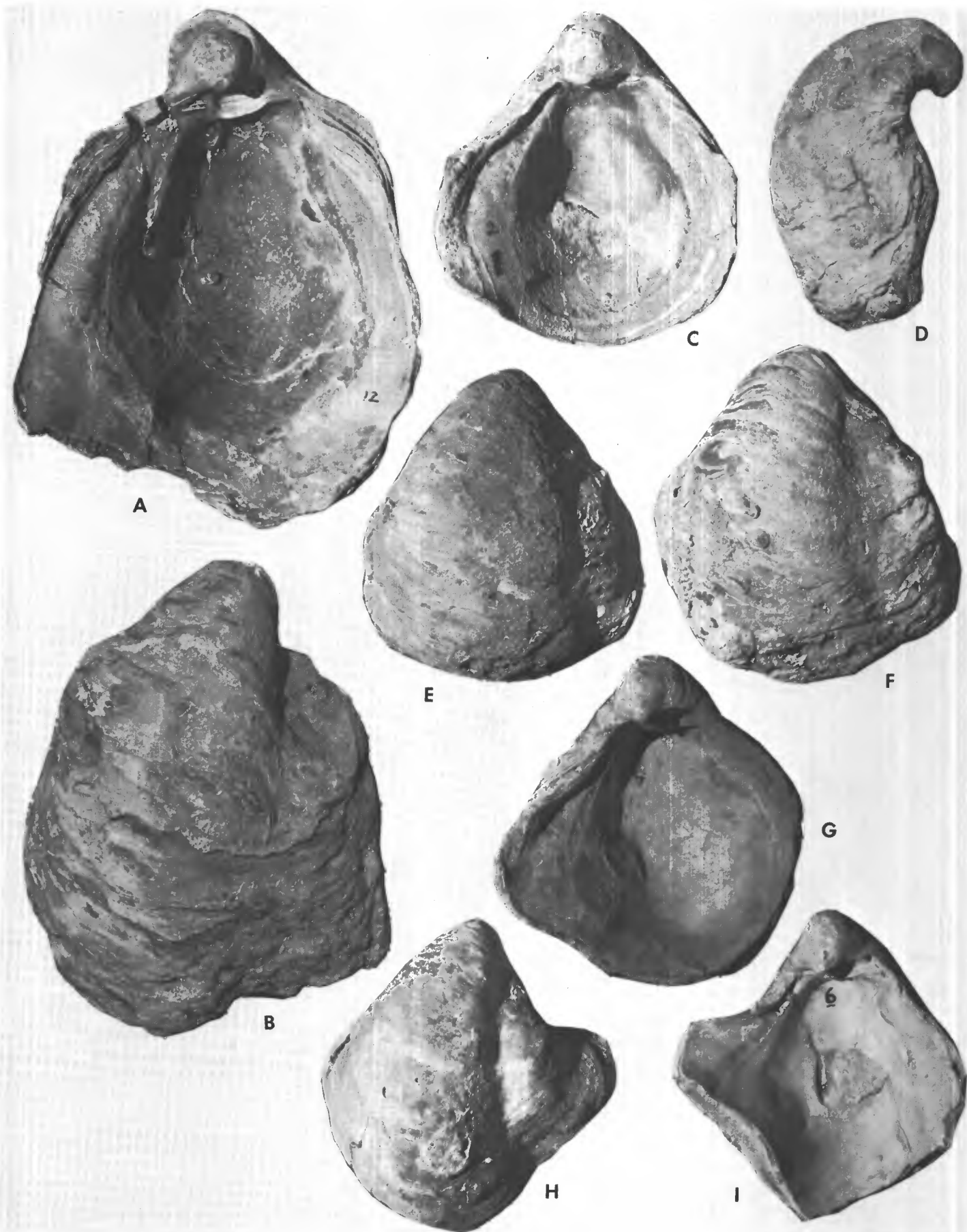
ANNOTATED CATALOG OF BIOTA

Introduction

The following annotated catalog includes all taxa reported from the Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale of east-central New Mexico. Taxa mentioned in unpublished reports, such as theses, and in other papers in this guidebook are omitted. Information presented for each taxon consists of references to all papers known to us that cite the taxon from east-central New Mexico, together with the stratigraphic occurrence, localities and other data reported by each author in documenting the taxon from this area. Each taxon is listed under the name by which it is currently known, insofar as that could be determined, but other names used by earlier workers are also cited. The locality information is either that reported by the authors citing the taxon, or a shortened statement of the locality keyed to the locality list (Appendix 1). Species that were originally established on the basis of east-central New Mexico specimens are indicated with an asterisk, and the location and number of the type specimen(s) is given.

The great majority of taxa listed here have been reported only from the Tucumcari Shale; the Mesa Rica Sandstone and Pajarito Shale contain biotas that are either poorly documented or unstudied. The stratigraphic information provided by each author is given as it appeared in his publication, but, unless otherwise indicated, all occurrences are from the marine shale unit presently known as the Tucumcari Shale. Only a few of the New Mexico occurrences of these taxa have been

FIGURE 6. Left valves (topotypes) of *Texigryphaea tucumcarii* (Marcou) from Tucumcari Shale of Pyramid Mountain, all $\times 1$. A, B, Internal and external views of UNM 9075, a relatively elongate specimen similar to the holotype. C-E, Internal, side, and external views of UNM 9076, a typical, relatively broad specimen with subdued sulcus and posterior flange. F, G, External and internal views of UNM 9077, a specimen with a moderate posterior flange. H, I, External and internal views of UNM 9078, *T. tucumcarii*?, with a strong posterior flange, concave postero-dorsal margin, and prominent sulcus.



adequately documented by fuller descriptions and illustrations; most of the species known from the Lower Cretaceous of east-central New Mexico have merely been cited in faunal lists.

In the most recent comprehensive study of the Tucumcari Shale biota, Scott (1974) discussed several paleocommunities that were shown to have a wide geographic distribution in Albian units not only in New Mexico but also in Colorado, Oklahoma and Kansas. Because his emphasis in this paper was on the ecological relationships of these biotas, data indicating precisely which taxa occurred at each New Mexico locality, as opposed to constituents of the paleocommunities that were not found within the state, were not presented. Scott (written comm. 1985) kindly made available some of his unpublished data concerning the species collected from New Mexico localities of the Tucumcari Shale, and this has been incorporated into the following list.

Protista

Acritarchs

TRAUGER ET AL., 1972, p. 26, shale possibly correlative with the Pajarito Shale, along NM-39, 8.2 mi (13.1 km) east of Mosquero (Loc. 41); KELLEY & KELLEY, 1972, pp. 47–48, Tucumcari Shale, I-40 roadcut 7.9 mi (12.6 km) west of Tucumcari (Loc. 42).

Cribratina texana (Conrad, 1857)

SCOTT, 1974, p. 322, Tucumcari Formation, 9 mi (14.4 km) south of San Jon (Loc. 25).

Foraminifera, indeterminate

KELLEY & KELLEY, 1972, pp. 47, 48, as “foraminifera test linings of megaspheric [sic] stages,” top of Tucumcari Shale, I-40 roadcut 7.9 mi (12.6 km) west of Tucumcari (Loc. 42). NOTE: See also unpublished M.S. thesis by Brooks (1959) and Kietzke (1985).

Plantae

Camarazonosporites sp.

KELLEY & KELLEY, 1972, p. 48, top of Tucumcari Shale, I-40 roadcut 7.9 mi (12.6 km) west of Tucumcari (Loc. 42).

Palynomorphs

KELLEY & KELLEY, 1972, pp. 47–48, as moss, fern and lycopod spores, several species of conifer pollen and one species of angiosperm pollen, top of Tucumcari Shale, I-40 roadcut 7.9 mi (12.6 km) west of Tucumcari (Loc. 42).

Plants, indeterminate

TRAUGER & BUSHMAN, 1964, p. 27, silicified wood, Mesa Rica Sandstone, about 3 mi (4.8 km) northwest of Tucumcari (Loc. 34); TRAUGER ET AL., 1972, p. 26, fragmental plant cuticle and conifer wood tissues, shale possibly correlative with the Pajarito Shale, along NM-39, 8.2 mi (13.1 km) east of Mosquero (Loc. 41); GAGE & ASQUITH, 1977, p. 8, silicified-wood fragments up to 2 ft long, Mesa Rica Sandstone, and indeterminate plant and wood fragments, Pajarito Shale, Tucumcari area.

Sterculia drakei

See *Sterculia townneri*.

Sterculia snowii

See *Sterculia townneri*.

Sterculia townneri (Lesquereux, 1875)

CUMMINS, 1892, p. 210, fig. 8, as *S. drakei*, n.sp., upper sandstone of Tucumcari beds (= Mesa Rica), 4 mi (6.4 km) west of Big Tucumcari Mountain (Loc. 3); MARCOU, 1892, p. 375, as *S. drakei*, questions Cretaceous age assignment; ANONYMOUS, 1892, p. 312, as *S. drakei*, quoted from Cummins (1892); CUMMINS, 1893, p. 283, as *S. drakei*; MARCOU, 1893b,

pp. 358–359, as *S. drakei*, quoted from Cummins (1892); ANONYMOUS, 1893, p. 327, as *S. drakei*, reference to Cummins (1892); KNOWLTON, 1894, p. 372, as *S. snowii*, “a characteristic plant of the Dakota group”; HILL, 1895, p. 232, as *S. snowii*, reported a letter from N. F. Drake, who collected the specimen and stated that Cummins’ *S. drakei* came from the basal sandstone below the mollusc-bearing beds rather than from the upper sandstone; KNOWLTON, 1919, p. 611, as *S. snowii*, Dakota, Big Tucumcari Mountain; STANTON, 1928, p. 407, as “dicotyledonous plants,” Washita equivalent, in a thin basal sandstone below the Washita marine shale and sandstone, Tucumcari area; LA MOTTE, 1944, pp. 296–297, as *S. townneri*, stating that both *S. drakei* and *S. snowii* are synonyms of *S. townneri*. NOTE: The stratigraphic position of this leaf is still unclear. Hill’s (1895) report would place the leaf below the Tucumcari Shale, possibly in the Morrison Formation, which is unlikely because of the questionable presence of any angiosperms in the Jurassic. Scott (1970a) reported a 12-ft-thick, unfossiliferous, crossbedded sandstone unit beneath the typical Tucumcari Shale that had been included in the Morrison by Dobrovolny et al. (1946), but which Scott (1970a) believed to be the basal Tucumcari on Tucumcari Mountain. This could be the basal sandstone referred to by Hill. On the other hand, the Dakota affinities of *S. townneri*, and the presence of fragmentary plants in the Mesa Rica Sandstone in the Tucumcari area, are consistent with Cummins’ original determination of the stratigraphic position of this leaf as being above the mollusc-bearing beds of the Tucumcari Shale.

Porifera

Cliona sp.

SCOTT, 1974, p. 322, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36).

Coelenterata

Desmophyllum? texanum (Conrad, 1857)

HILL, 1893, p. 24, as *Turbinolia texana*, Unit 4 of Washita division, Tucumcari Mesa, included in a faunal list from this locality, but later in the paper also stated that it had “not been reported east of the Pecos, but it occurs near El Paso, and at Arivichi, Sonora . . . associated with a fauna similar to that of Tucumcari.” This suggests that Hill perhaps did not see this coral in the Tucumcari area; CRAGIN, 1895, p. 383, as *T. texana*, Washita division, Tucumcari district; HILL, 1895, p. 230, as *T. texana*(?), shaly beds below the Dakota, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, as *T. texana*, quoted from Hill (1895); DARTON, 1928, p. 39, as *T. texana*?, Purgatoire Formation, vicinity of Tucumcari; WELLS, 1933, p. 52, as *Coelosmilium texana*, but did not report it from the Tucumcari area. NOTE: Wells (1956) considered *Coelosmilium* a synonym of *Desmophyllum*.

Platycyathus scottianus Wells, 1933

SCOTT, 1985 (written comm.), Tucumcari Formation, San Jon section (Loc. 25).

Bryozoa

Membraniporidae

SCOTT, 1974, pp. 322, 328, as bryozoans and membraniporid bryozoans, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36).

Brachiopoda

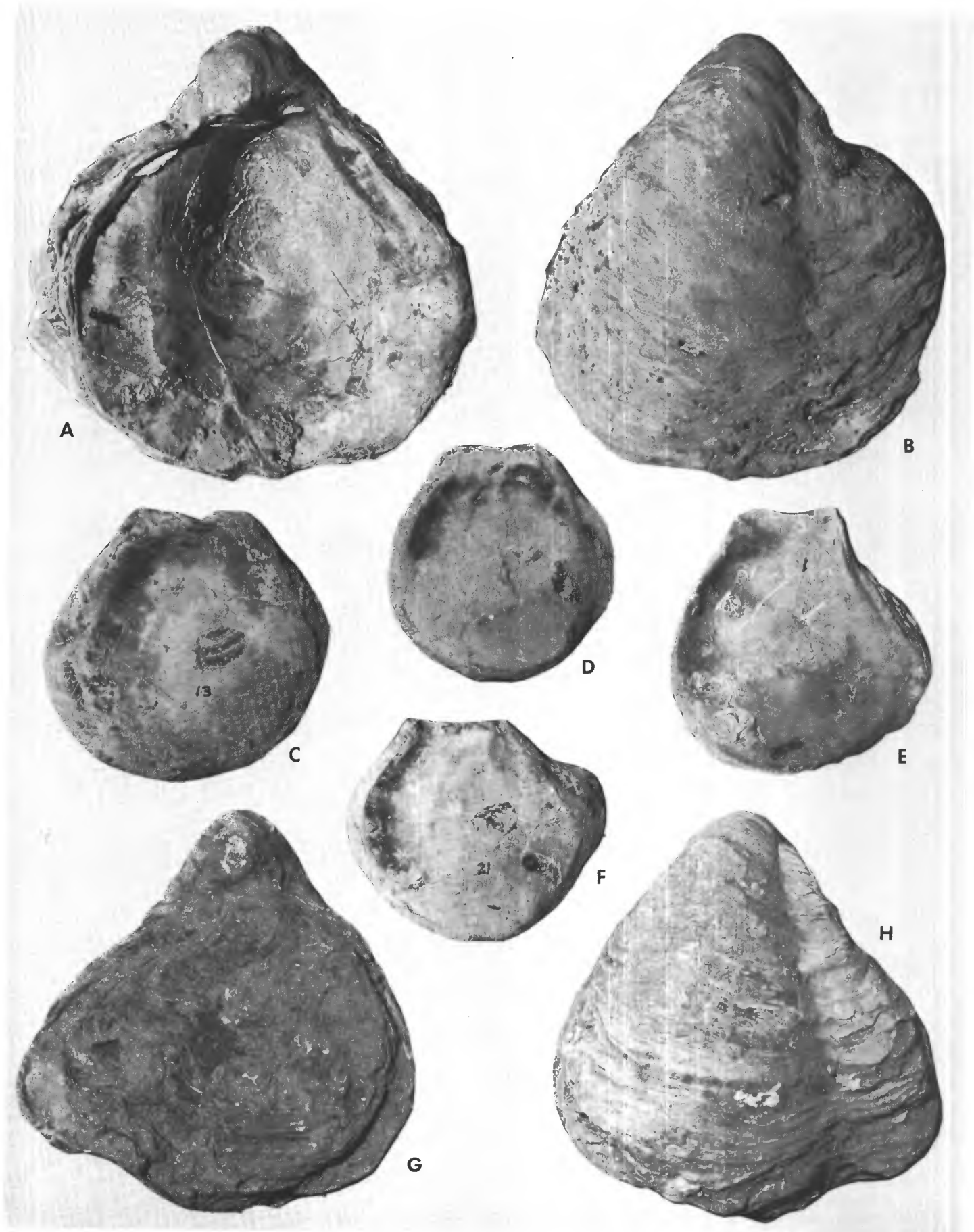
Lingula subspatulata Hall & Meek, 1854

SCOTT, 1970a, p. 1240, as *Lingula* sp., Tucumcari Formation, Tucumcari area; SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

Lingula sp.

See *L. subspatulata*.

FIGURE 7. *Texigryphaea tucumcarii* (Marcou) from the Tucumcari Shale, all $\times 1$. A, B, Internal and external views of UNM 9079, a broad left valve (topotype) with subdued posterior flange and sulcus, Pyramid Mountain; note numerous clonid sponge borings at base of external surface. C–F, Internal views of UNM 9080–9083, right valves (topotypes), showing variation in shape from nearly circular to strongly flanged, Pyramid Mountain. G, H, Dorsal and ventral views of an articulated specimen, UNM 9084, San Jon section (locality 25).



Annelida

Serpula sp.

SCOTT, 1974, p. 322, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35).

Serpula? sp.

ASH & CLEBSCH, 1961, p. D-139, Tucumcari Shale, about 11 mi (17.6 km) north of Tatum (Loc. 29).

Mollusca: Gastropoda

Amberleya ?mudgeana (Meek, 1871)

STANTON, 1947, p. 57, Purgatoire Formation, Monte Revuelto (Loc. 13).

Atira? sp.

SCOTT, 1985 (written comm.), Tucumcari Shale, east side of Liberty Mesa (Loc. 36).

**Cassiope hyatti* Stanton, 1947

STANTON, 1947, p. 78 and taxon-distribution chart, pl. 57, figs. 12–13, 19, Purgatoire Formation, Tucumcari Mountain (Loc. 2), Monte Revuelto (Loc. 13). Described as a new species with Tucumcari Mountain as the type locality. TYPES: Syntypes, USNM (National Museum of Natural History, Washington, D.C.) 77630a–c.

Drepanochilus kiowanus (Cragin, 1894)

SCOTT, 1970a, p. 1240, as *Drepanochilus* sp., Tucumcari Formation, Tucumcari area; SCOTT, 1974, pp. 323, 325, Tucumcari Formation, San Jon section (Loc. 25).

Drepanochilus sp.

See *D. kiowanus*.

Turbo? newberryi (Cragin, 1894)

STANTON, 1947, p. 56 and taxon-distribution chart, pl. 49, fig. 6, Purgatoire Formation, Tucumcari Mountain (Loc. 2).

**Turbo? revueltensis* Stanton, 1947

STANTON, 1947, p. 56 and taxon-distribution chart, pl. 49, fig. 10, Purgatoire Formation, Monte Revuelto (Loc. 13). Described as a new species. TYPES: Holotype, USNM (National Museum of Natural History, Washington, D.C.) 103136.

Turritella belviderei Cragin, 1897

SCOTT, 1974, p. 323, as *T. belviderensis*, Tucumcari Formation, San Jon section (Loc. 25).

Turritella ?marnochi White

See *T. seriatimgranulata*.

Turritella seriatimgranulata Roemer, 1849

CUMMINS, 1892, pp. 208–209, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; MARCOU, 1892, p. 374, questions its Cretaceous occurrence in Tucumcari area; ANONYMOUS, 1892, p. 311, quoted from Cummins (1892); HILL, 1893, p. 24, as *T. marnochi* or *T. seriatim-granulata*, Unit 4 (Washita division), Tucumcari Mesa; HILL, 1895, pp. 230–231, as *T. seriatim-granulata* and *T. marnochi* or *T. seriatim-granulata*, shaly beds below the Dakota, Tucumcari area; STANTON & VAUGHAN, 1896, p. 25, as *T. seriatim-granulata* and *T. marnochi?*, quoted from Hill (1895); BULLARD, 1928, p. 95, Purgatoire Formation, Tucumcari region; DARTON,

1928, p. 39, Purgatoire Formation, Tucumcari region; ADKINS, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain; DOBROVOLNY ET AL., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; STANTON, 1947, pp. 75–76 and taxon-distribution chart, pl. 56, figs. 19, 21, Purgatoire Formation, Mesa Tucumcari (Loc. 2), noted that some specimens assigned to *T. marnochi* in the past are *T. seriatim-granulata*; BRAND, 1953, p. 15, Tucumcari Shale Member, Purgatoire Formation, Quay County; BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area and San Jon section (Loc. 25); JACKA & BRAND, 1973, p. 48, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; SCOTT, 1974, pp. 323, 328, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35) and east side of Liberty Mesa (Loc. 36); KAUFFMAN, 1977, pp. 227–228, pl. 1, figs. 15, 16 (copies of Stanton, 1947, pl. 56, figs. 21, 19), Purgatoire Formation, Mesa Tucumcari (Loc. 2).

Turritella sp.

BAKER, 1920, pp. 120–121, upper Tucumcari beds, Tucumcari Mountain (Loc. 2) and 11.5 mi (18.4 km) west of Tucumcari on the Montoya Road (Loc. 6); ADKINS, 1927, p. 56, top of sandstones beneath "Dakota," Tucumcari Mountain (Loc. 2); DARTON, 1928, p. 290, Purgatoire Formation, Cuervo Hill (Loc. 11); ADKINS, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2); SCOTT, 1970a, p. 1240, Tucumcari Formation, Tucumcari area; BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area.

Tylostoma sp.

BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area.

Mollusca: Bivalvia

Alectryonia quadriplicata

See *Lopha quadriplicata*.

Alectryonia subovata

See *Lopha subovata*.

Arca n.sp.

SCOTT, 1985 (written comm.), Tucumcari Formation, San Jon section (Loc. 25).

Astarte? sp.

MARCOU, 1855a, p. 44, as *Cardinia*, Jurassic, Tucumcari area; BLAKE, 1856a, p. 81, as *Cardinia*, quoted from Marcou (1855a); MARCOU, 1858a, p. 20, as *Astarte* sp., Jurassic, Tucumcari area; DANA, 1858, p. 330, as *Astarte* sp., quoted from Marcou (1858a); HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2). NOTE: The absence of recent reports of this genus from the Tucumcari area suggests that the specimens so designated represent a different genus.

Botula sp.

SCOTT, 1974, pp. 322, 328, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36).

Breviarca angulata Scott, 1970

SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

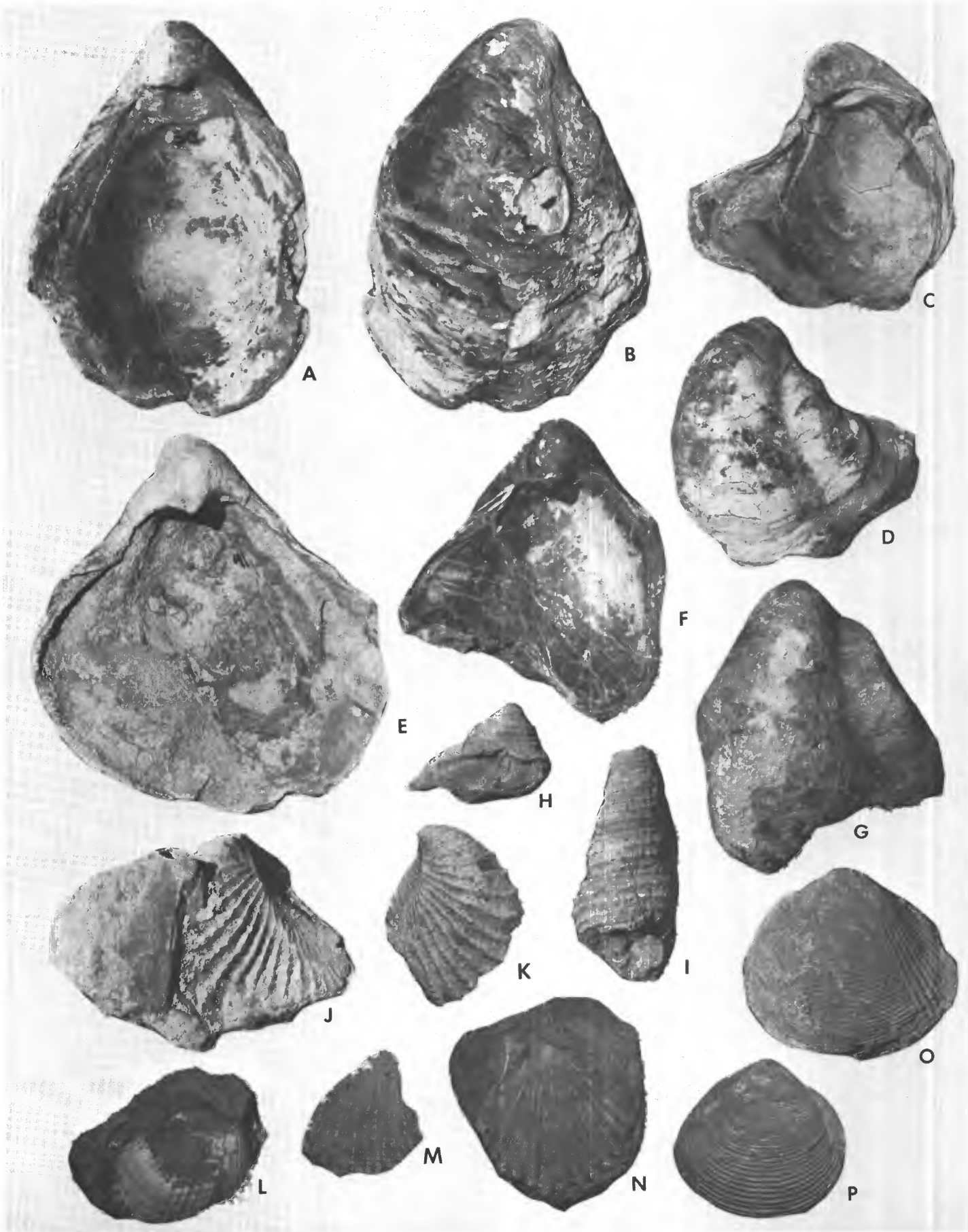
Breviarca habita Stephenson, 1952

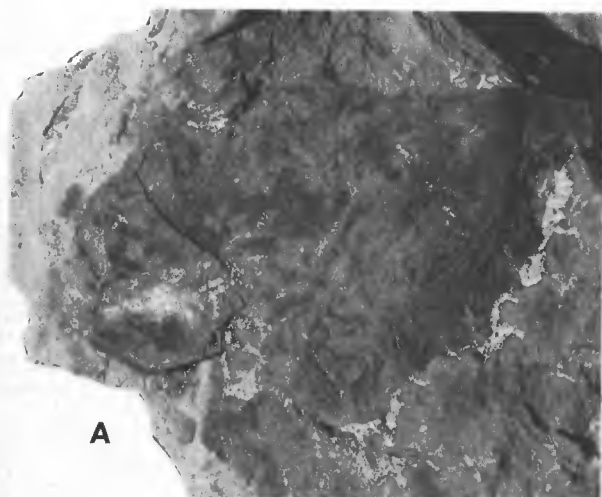
SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

Breviarca subovata Scott, 1970

SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

FIGURE 8. Molluscs from the Tucumcari Shale and Mesa Rica Sandstone, all $\times 1$. A, B, *Texigryphaea* cf. *T. tucumcarii* (Marcou), internal and external views of left valve UNM 9085, Tucumcari Shale, about 9 mi (14 km) west of Tucumcari (locality 28). C, D, *Texigryphaea* sp., internal and external views of left valve with strongly curved beak, UNM 9086, Tucumcari Shale, Bull Canyon area (locality 53). E, *Texigryphaea tucumcarii* (Marcou), internal view of a broad left valve, UNM 9087, Tucumcari Shale (locality 28). F, G, *Texigryphaea tucumcarii* (Marcou), internal and external views of an elongate left valve with prominent posterior carina and sulcus, UNM 9088, Tucumcari Shale, Bull Canyon area (locality 52). H, *Amberleya mudgeana* (Meek), side view, UNM 9089, Tucumcari Shale, south of Mesa Quemado (locality 50). I, *Turritella seriatimgranulata* Roemer, side view of an incomplete specimen, UNM 9090 (locality 50). J, K, *Scabrotrigonia emoryi* (Conrad), J, incomplete left valve, UNM 9091, Tucumcari Shale (locality 50). K, incomplete right valve, unnumbered USGS specimen, basal Mesa Rica Sandstone, southwest of Apache Canyon (locality 44). L, *Lima wacoensis* Roemer, unnumbered USGS specimen, basal Mesa Rica Sandstone (locality 44). M, N, *Neithea texana* (Roemer), right valve and interior of left valve, unnumbered USGS specimens, basal Mesa Rica Sandstone (locality 44). O, P, *Protocardia texana* (Conrad); O, left valve, UNM 9092, Tucumcari Shale (locality 50), P, right valve, unnumbered USGS specimen, basal Mesa Rica Sandstone (locality 44).





A



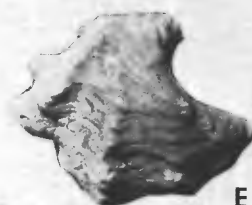
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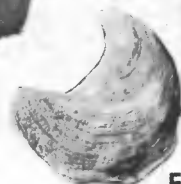
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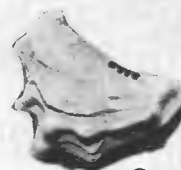
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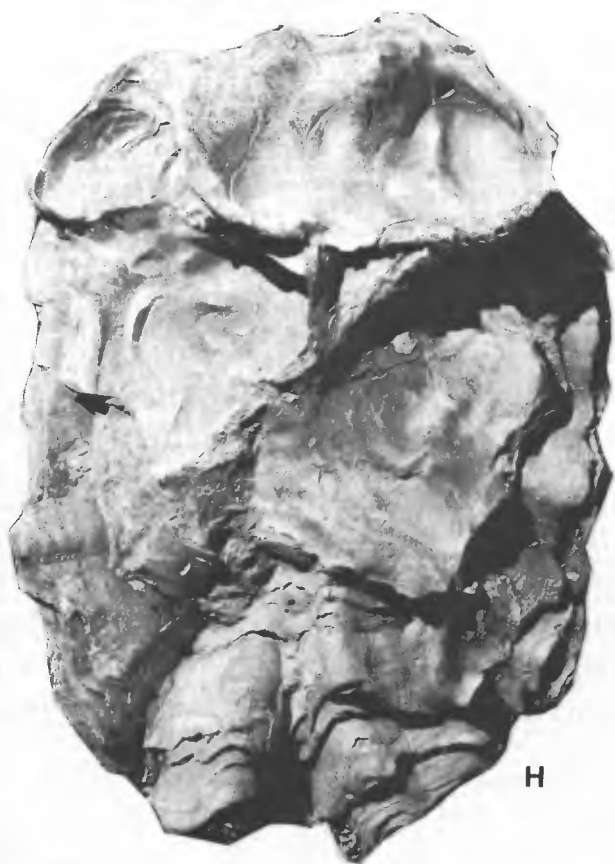
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I



FIGURE 10. Slabs of Pajarito Shale from escarpment of Llano Estacado south-west of Puerto Canyon (locality 57), with *Loph quadruplicata* (Shumard), unnumbered USGS specimens, $\times 1$.

Breviarca spp.

SCOTT, 1970a, p. 1240, as *B. sp.*, Tucumcari Formation, Tucumcari area; SCOTT, 1974, p. 323, as *B. sp.* and *B. n.sp.*, Tucumcari Formation, San Jon section (Loc. 25).

Cardinia sp.

See *Astarte*? sp.

Cardita? belviderensis Cragin, 1894

Cragin, 1894, p. 6, Lower Cretaceous, Tucumcari district; Hill, 1895, p. 230, upper Tucumcari beds, Tucumcari area; Cragin, 1895, p. 370, Kiowa-equivalent shales, Tucumcari area; Stanton & Vaughan, 1896, p. 25, quoted from Hill (1895); Bullard, 1928, p. 95, Purgatoire Formation, Tucumcari region; Darton, 1928, p. 39, Purgatoire Formation, vicinity of Tucumcari; Adkins, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2); Dobrovolsky et al., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; Brand, 1953, p. 15, Tucumcari Shale Member of Purgatoire Formation, Quay County; Brand & Mattox, 1972, p. 101, Tucumcari Shale, Tucumcari area; Jacka & Brand, 1973, p. 48, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; Scott, 1974, p. 323 as *C. belviderensis*, p. 328 as *Cardita?* sp., Tucumcari Formation, Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36).

Cardita? sp.

See *Cardita? belvidernensis*.

Cardium hillanum

See *Protocardia texana*.

Cardium sp.

Baker, 1920, pp. 120–121, upper Tucumcari beds, Tucumcari Mountain (Loc. 2) and 11.5 mi (18.4 km) west of Tucumcari (Loc. 6); Adkins, 1927, p. 57, top of unit below Dakota, Tucumcari Mountain (Loc. 2); Adkins, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2). NOTE: According to Keen (1969a), true *Cardium* is not present in the Cretaceous. Specimens identified as *Cardium* probably represent species of *Protocardia* but would have to be examined to be certain.

Ceratostreon texanum (Roemer, 1849)

Cummins, 1892, p. 208, as *Exogyra texana*, Tucumcari beds, vicinity of

Tucumcari and Pyramid Mountains; Marcou, 1892, pp. 374–375, as *E. texana*, questions Cretaceous occurrence in Tucumcari area; Anonymous, 1892, p. 311, as *E. texana*, quoted from Cummins (1892); Marcou, 1893b, pp. 358–359, as *E. texana*, doubts Cummins' (1892) identification; Cummins, 1893, p. 283, as *E. texana*, Cretaceous, Tucumcari Mountain (Loc. 2); Hill, 1895, pp. 230–231, as *E. texana*, upper Tucumcari beds, Tucumcari region; Stanton & Vaughan, 1896, p. 25, as *E. texana*, quoted from Hill (1895); Bullard, 1928, p. 95, as *E. texana*, Purgatoire Formation, Tucumcari region; Darton, 1928, p. 39, as *E. texana*, Purgatoire Formation, vicinity of Tucumcari; Adkins, 1932, p. 281, as *E. texana*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); Dobrovolsky et al., 1946, as *E. texana*, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; Brand, 1953, p. 15, as *E. texana*, Tucumcari Shale Member of Purgatoire Formation, Quay County; Ash & Clebsch, 1961, p. D-139, as *E. texana*, Tucumcari Shale, 11 mi (17.6 km) north of Tatum (Loc. 29); Brand & Mattox, 1972, pp. 101–102, as *E. texana*, Tucumcari Shale, Tucumcari area and San Jon section (Loc. 25); Jacka & Brand, 1973, p. 47, as *E. texana*, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; Scott, 1985 (written comm.), not observed in Tucumcari Shale.

Ceratostreon sp.

Trauger & Bushman, 1964, p. 26, as *Exogyra* sp., Tucumcari Shale, 6 mi (9.6 km) west-southwest of Tucumcari (Loc. 33).

Corbula crassicostata Cragin, 1894

Scott, 1974, p. 322, Tucumcari Formation, San Jon section (Loc. 25).

Corbula? smolenensis (Twenhofel & Tester, 1926)

Scott, 1974, pp. 323, 326, 327, Tucumcari Formation, San Jon section (Loc. 25).

Corbulidae

Scott, 1974, pp. 323, 325, Tucumcari Formation, San Jon section (Loc. 25).

Crassatellina oblonga Meek, 1871

Scott, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

Cucullaea recedens Cragin, 1894

Scott, 1974, pp. 323, 328, Tucumcari Formation, Tucumcari Mountain (Loc. 35).

Cyprimeria texana (Roemer, 1852)

Scott, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25), east side of Liberty Mesa (Loc. 36).

Cyprimeria sp.

Hill, 1895, p. 230, upper Tucumcari beds, Tucumcari region; Stanton & Vaughan, 1896, p. 25, quoted from Hill (1895); Bullard, 1928, p. 95, Purgatoire Formation, Tucumcari region; Darton, 1928, p. 39, Purgatoire Formation, vicinity of Tucumcari; Adkins, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2); Dobrovolsky et al., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; Brand, 1953, p. 15, Tucumcari Shale Member of Purgatoire Formation, Quay County; Brand & Mattox, 1972, p. 101, Tucumcari Shale, Tucumcari area; Jacka & Brand, 1973, p. 48, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin.

"Cytherea" leonensis Conrad, 1857

Cummins, 1892, pp. 208–209, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; Marcou, 1892, p. 374, questions Cretaceous occurrence in Tucumcari area; Anonymous, 1892, p. 311, quoted from Cummins (1892); Cummins, 1893, p. 283, Cretaceous, Tucumcari Mountain (Loc. 2); Marcou, 1893b, p. 358, doubts Cummins' (1892) identification; Hill, 1895, pp. 230–231, upper Tucumcari beds, Tucumcari region; Stanton & Vaughan, 1896, p. 25, quoted from Hill (1895); Darton, 1928,

FIGURE 9. Molluscs from the Tucumcari Shale and Mesa Rica Sandstone, all $\times 1$ unless otherwise indicated. A, *Pteria* aff. *P. salinensis* White, right valve, UNM 9093, Tucumcari Shale (locality 50). B, *Siliqua?* sp., right valve, unnumbered USGS specimen, basal Mesa Rica Sandstone (locality 44). C, D, *Homomya* sp., right sides, unnumbered USGS specimens, basal Mesa Rica Sandstone (locality 44). E–G, *Loph quadruplicata* (Shumard), left, right and left valves of UNM 9094, 9095 and 9096, respectively, Tucumcari Shale (locality 50). H, *Loph subovata* (Shumard), right valve (upper part obscured by cemented ostreid valves), UNM 9097, Tucumcari Shale, Pyramid Mountain. I, *Mortoniceras equidistans* (Cragin), UNM 9098, basal Mesa Rica Sandstone, Bull Canyon area (locality 52), $\times 0.5$.

p. 39, Purgatoire Formation, vicinity of Tucumcari. NOTE: According to Keen (1969b), *Cytherea* is not a valid genus and species formerly assigned to it have been distributed among several venerid genera. We have not encountered "*Cytherea*" *leonensis* in the recent literature and regard the generic status of the species as uncertain. Specimens assigned to "*Cytherea*" *leonensis* by the authors cited above may be *Flaventia belviderensis* or a species of *Cyprimeria*.

"Exogyra" plexa Cragin, 1893

ASH & CLEBSCH, 1961, p. D-139, Tucumcari Shale, 11 mi (17.6 km) north of Tatum (Loc. 29).

Exogyra texana

See *Ceratostreon texanum*.

Exogyra sp.

See *Ceratostreon* sp.

Flaventia belviderensis (Cragin, 1894)

HILL, 1895, p. 230, as *Tapes belviderensis*, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, as *T. belviderensis*, quoted from Hill (1895); BULLARD, 1928, p. 95, as *T. belviderensis*, Purgatoire Formation, Tucumcari region; DARTON, 1928, p. 39, as *T. belviderensis*, Purgatoire Formation, vicinity of Tucumcari; ADKINS, 1932, p. 281, as *T. belviderensis*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, as *T. belviderensis*, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; BRAND, 1953, p. 15, as *T. belviderensis*, Tucumcari Shale Member of Purgatoire Formation, Quay County; BRAND & MATTOX, 1972, p. 101, as *T. belviderensis*, Tucumcari Shale, Tucumcari area; JACKA & BRAND, 1973, p. 48, as *T. belviderensis*, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; SCOTT, 1974, pp. 323, 328, Tucumcari Formation, Tucumcari Mountain (Loc. 35).

Flaventia sp.

SCOTT, 1970, p. 1233, Tucumcari Formation, San Jon section (Loc. 25); SCOTT, 1985 (written comm.), Tucumcari Formation, Tucumcari Mountain (Loc. 35).

Gryphaea corrugata

See *Texigryphaea pitcheri* and *T. tucumcarii*.

Gryphaea corrugata var. tucumcarii

See *Texigryphaea tucumcarii*.

Gryphaea dilatata

See *Texigryphaea tucumcarii*.

Gryphaea dilatata var. tucumcarii

See *Texigryphaea tucumcarii*.

Gryphaea marcoui

See *Texigryphaea mucronata*.

Gryphaea pitcheri

See *Texigryphaea pitcheri* and *T. tucumcarii*.

Gryphaea tucumcarii

See *Texigryphaea tucumcarii*.

Gryphaea sp.

See *Texigryphaea* sp.

Homomya sp.

SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

Inoceramus bellvuensis Reeside, 1923

SCOTT, 1969b, p. 26, upper Tucumcari Formation, Tucumcari area; SCOTT, 1970a, p. 1236, Tucumcari Formation, Tucumcari area (San Jon section and east side of Liberty Mesa: Scott, 1985, written comm.).

Inoceramus comancheanus Cragin, 1894

SCOTT, 1969b, p. 25, lower Tucumcari Formation, Tucumcari area; SCOTT,

1970a, pp. 1228, 1233, 1234, Tucumcari Formation, near Tucumcari and San Jon section (Loc. 25).

Inoceramus sp.

SIMPSON, 1850, p. 17, Cretaceous, Plaza Larga Creek, southwest of Tucumcari Mountain; BRAND & MATTOX, 1972, p. 102, as *Inoceramus*(?) sp., Tucumcari Shale, San Jon section (Loc. 25).

Isocardia? sp.

HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2). NOTE: According to Keen and Casey (1969), *Isocardia* is a synonym of *Glossus*, which is not present in the Cretaceous. The identity of specimens referred to *Isocardia*? sp. is uncertain.

Leptosolen conradi Meek, 1871

SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

Lima utahensis Stanton, 1893

SCOTT, 1974, pp. 323, 328, Tucumcari Formation, San Jon section (Loc. 25).

Lima wacoensis Roemer, 1849

STANTON, 1947, taxon-distribution chart, Purgatoire Formation, Tucumcari Mountain (Loc. 2), Monte Revuelto (Loc. 13).

Lopha marcoui (Böse)

See *Lopha subovata*.

Lopha quadriplicata (Shumard, 1859)

CUMMINS, 1892, pp. 208–209, as *Ostrea quadriplicata*, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; MARCOU, 1892, p. 374, as *O. quadriplicata*, questions Cretaceous occurrence in Tucumcari area; ANONYMOUS, 1892, p. 311, as *O. quadriplicata*, quoted from Cummins (1892); CUMMINS, 1893, p. 283, as *O. quadriplicata*, Cretaceous, Tucumcari Mountain (Loc. 2); MARCOU, 1893b, p. 358, as *O. quadriplicata*, doubts Cummins' (1892) identification; HILL, 1893, p. 24, as *O. quadricostata* [meaning *quadriplicata*], Unit 4 (Washita division), Tucumcari Mesa (Loc. 2); HILL, 1895, pp. 230, 233, as *O. quadriplicata*, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, as *O. quadriplicata*, quoted from Hill (1895); BAKER, 1920, p. 121, as *O. quadriplicata*, Tucumcari beds, 11.5 mi (18.4 km) west of Tucumcari (Loc. 6); ADKINS, 1927, p. 56, as *Alectryonia quadriplicata*, [Tucumcari beds], near Tucumcari; BULLARD, 1928, pp. 95–96, as *Ostrea quadriplicata*, Purgatoire Formation, Tucumcari region; DARTON, 1928, pp. 39, 290, 300, as *O. quadriplicata*, Purgatoire Formation, vicinity of Tucumcari, Cuervo Hill (Loc. 11), 3 mi (4.8 km) south of Montoya (Loc. 7); ADKINS, 1932, p. 281, as *O. quadriplicata*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, as *O. quadriplicata*, Tucumcari Shale Member and Pajarito Shale Member of Purgatoire Formation, northwest Quay County; STANTON, 1947, p. 24 and taxon-distribution chart, as *O. quadriplicata*, Purgatoire Formation, Tucumcari area (Localities 2, 12, 13, 15); BRAND, 1953, p. 15, as *O. quadriplicata*, Tucumcari Shale and Pajarito Shale Members of Purgatoire Formation, Quay County; GRIGGS & READ, 1959, p. 2007, as *O. quadriplicata*, Pajarito Shale, Tucumcari area; SCOTT, 1969b, p. 26, upper Tucumcari Formation, northeast New Mexico; SCOTT, 1970a, pp. 1233–1234, Pajarito Shale, Tucumcari area; BRAND & MATTOX, 1972, pp. 101, 103, as *Ostrea quadriplicata*, Tucumcari Shale and Pajarito Shale, Tucumcari area; JACKA & BRAND, 1973, p. 47, as *O. quadriplicata*, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; SCOTT, 1974, pp. 322, 328, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36); GAGE & ASQUITH, 1977, p. 8, Pajarito Shale, San Jon area.

Lopha subovata (Shumard, 1853)

MARCOU, 1855a, p. 44, as *Ostrea marshii*, Jurassic, Tucumcari area; MARCOU, 1855b, pl. 21, fig. 4, as *O. marshii*, Jurassic, Tucumcari area; BLAKE, 1856a, p. 81, as *O. marshii*, quoted from Marcou (1855a); BLAKE, 1856b, p. 137, as *O. marshii* [sic], Jurassic, Pyramid Mountain (Loc. 1); BLAKE, 1856c, p. 386, as *O. marshii* of Marcou, Cretaceous, Pyramid Mountain (Loc. 1); MEEK & HAYDEN, 1857, p. 132, as *O. subovata*, Cretaceous Unit 2, Pyramid Mountain (Loc. 1); HALL, 1857a, p. 135, as *O. marshii* of Marcou, Nebraska Cretaceous Units 2 & 3, Pyramid Mountain (Loc. 1); HALL, 1857b, pp. 84–85, as *O. subovata*, Nebraska Cretaceous Units 2 & 3, Pyramid Mountain (Loc. 1); MARCOU, 1858a, pp. 19–20, 43–44, pl. 4,

- fig. 4, as *O. marshii*, Jurassic, Pyramid Mountain (Loc. 1); MARCOU, 1858b, pp. 4–7, rejects Meek & Hayden's opinion that *O. marshii* is *O. subovata*; DANA, 1858, p. 330, as *O. subovata*, Cretaceous, Llano Estacado; SHUMARD, 1860, p. 587, as *O. subovata*, Nebraska Cretaceous Unit 3 equivalent, Pyramid Mountain (Loc. 1); ANONYMOUS, 1861, p. 127, as *O. marshii* of Marcou, Cretaceous Units 2 & 3 [Tucumcari area]; MARCOU, 1861b, p. 548, as *O. marshii*, Jurassic, Pyramid Mountain (Loc. 1); GABB, 1861, p. 549, as *O. subovata*, Cretaceous, [Pyramid Mountain]; MARCOU, 1889, pp. 157, 217, as *O. marshii*, Jurassic, Pyramid Mountain (Loc. 1); CUMMINS, 1892, pp. 202, 204, 206, as *O. marshii* as determined by Marcou, seemingly identical to *O. subovata*, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains (Loc. 1, 2); HILL, 1892, p. 394, as *O. marshii* of Marcou, Comanchean, Mesa Tucumcari (Loc. 2); MARCOU, 1892, pp. 373–374, as *Ostrea* of the *O. marshii* form, and *O. marshii* as determined by Marcou, Jurassic, Pyramid Mountain (Loc. 1); ANONYMOUS, 1892, p. 311, as *O. marshii* as determined by Marcou, quoted from Cummins (1892); CUMMINS, 1893, p. 283, as *O. subovata*, Cretaceous, Tucumcari Mountain (Loc. 2); MARCOU, 1893a, pp. 213–214, as *O. marshii*, Jurassic, Tucumcari area; MARCOU, 1893b, pp. 358–359, as *O. marshii*, Jurassic, Tucumcari area, rejects Cretaceous age; HILL, 1895, pp. 230–231, as *O. marshii* as determined by Marcou (= *O. subovata*), upper Tucumcari beds, Tucumcari area; STANTON & VAUGHAN, 1896, p. 25, as *O. marshii* (= *O. subovata*), quoted from Hill (1895); MARCOU, 1897, pp. 205, 207, 208, 210, 212, as *O. marshii*, Jurassic, Pyramid Mountain (Loc. 1); HILL & VAUGHAN, 1898, p. 14, pl. 17, fig. 1 (= copy of Marcou, 1858a, pl. 4, fig. 4), as *O. marshii* of Marcou (= *O. subovata*), Jurassic (actually Cretaceous), Tucumcari Mesa [error for Pyramid Mountain]; ADKINS, 1927, p. 56, as *Alectryonia subovata*, [Tucumcari beds], near Tucumcari; DARTON, 1928, p. 39, as *O. marshii*, Purgatoire Formation, vicinity of Tucumcari; DOBROVOLNY ET AL., 1946, as *O. subovata*, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; STANTON, 1947, pp. 24–25, as *O. (Lopha) subovata*, Washita Group, Tucumcari Mountain (Loc. 2), considers *O. marcoui* and *O. marshii* of Marcou as synonyms of *O. subovata*; BRAND, 1953, p. 15, as *O. subovata*, Tucumcari Shale Member of Purgatoire Formation, Quay County; DEFORD, 1972, pp. 67, 68, 70, unnumbered figure on p. 68 (= copy of Marcou, 1858a, pl. 4, fig. 4), as *Lopha marcoui*, Tucumcari Shale, Tucumcari area; BRAND & MATTOX, 1972, p. 101, as *O. subovata*, Tucumcari Shale, Tucumcari area; JACKA & BRAND, 1973, p. 47, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin.
- Lopha ?subovata* (Shumard, 1853)**
 TRAUGER ET AL., 1972, p. 40, as *Ostrea subovata*?, Tucumcari Shale, along NM-88, 4.2 mi (6.7 km) north of its junction with NM-231 (Loc. 39).
- Lopha* cf. *L. subovata* (Shumard, 1853)**
 BULLARD, 1928, p. 95, as *Ostrea* cf. *subovata*, Purgatoire Formation, Tucumcari region; ADKINS, 1932, p. 281, as *O. cf. subovata*, Purgatoire Formation, Tucumcari Mountain (Loc. 2).
- Lucina?* sp.**
 HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2).
- Megalocardia?* sp.**
 SCOTT, 1974, p. 323, Tucumcari Formation, Tucumcari Mountain (Loc. 35).
- Neitheia occidentalis* Conrad, 1855**
 HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2); HILL, 1895, pp. 230–231, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, quoted from Hill (1895); BULLARD, 1928, p. 95, Purgatoire Formation, Tucumcari region; DARTON, 1928, p. 39, Purgatoire Formation, vicinity of Tucumcari; ADKINS, 1932, p. 281, as *Pecten occidentalis*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; STANTON, 1947, pp. 43–44 and taxon-distribution chart, as *Pecten (Neitheia) occidentalis*, Purgatoire Formation, near entrance to Apache Canyon (Loc. 14), Hondo Canyon on west side of Liberty Mesa (Loc. 16); BRAND, 1953, p. 15, Tucumcari Shale Member of Purgatoire Formation, Quay County; BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area; JACKA & BRAND, 1973, p. 47, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari region; SCOTT, 1974, p. 322, Tucumcari Formation, San Jon section (Loc. 25), east side of Liberty Mesa (Loc. 36).
- Neitheia texana* (Roemer, 1852)**
 STANTON, 1947, pp. 45–46, as *Pecten (Neitheia) texanus*, Washita equivalent, along northern edge of Staked Plains near Mesa Tucumcari; SCOTT, 1985 (written comm.), Tucumcari Formation, Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36).
- Neitheia ?texana* (Roemer, 1852)**
 ASH & CLEBSCH, 1961, p. D-139, Tucumcari Shale, 11 mi (17.6 km) north of Tatum (Loc. 29).
- Neitheia* sp.**
 CUMMINS, 1892, p. 208, as *Pecten* sp., Tucumcari beds, vicinity of Pyramid and Tucumcari Mountains; MARCOU, 1892, p. 374, as *Pecten* sp., quoted from Cummins (1892); ANONYMOUS, 1892, p. 311, as *Pecten* sp., quoted from Cummins (1892); TRAUGER ET AL., 1972, p. 41, as *Pecten (Neitheia)* sp. (?), Tucumcari Shale, along NM-88, 4.2 mi (6.7 km) north of its junction with NM-231 (Loc. 39).
- Neocrassina semicostata* (Scott, 1970)**
 SCOTT, 1974, pp. 323, 327, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35).
- Nucula* cf. *N. coloradoensis* Stanton, 1893**
 SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).
- Nucula* sp.**
 SCOTT, 1970a, p. 1240, Tucumcari Formation, Tucumcari area; SCOTT, 1974, p. 325, Tucumcari Formation, San Jon section (Loc. 25).
- Nuculana mutata* Stephenson, 1952**
 SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).
- Nuculana* sp.**
 SCOTT, 1970a, p. 1240, Tucumcari Formation, Tucumcari area.
- Ostrea aquila***
 See *Ostrea* sp.
- Ostrea dilatata***
 See *Texigryphaea tucumcarii*.
- Ostrea marshii***
 See *Lopha subovata*.
- Ostrea quadricostata***
 See *Lopha quadriplicata*.
- Ostrea quadriplicata***
 See *Lopha quadriplicata*.
- Ostrea subovata***
 See *Lopha subovata*.
- Ostrea* cf. *O. subovata***
 See *Lopha* cf. *L. subovata*.
- Ostrea* sp.**
 WHIPPLE, 1856, pp. 38–39, as “astrea” [sic], and “fossil oyster shells,” Mesozoic, Tucumcari area; BLAKE, 1856b, p. 137, as *Ostrea aquila* [a European species], Lower Cretaceous, east of Tucumcari Mountain. NOTE: These early reports of oysters probably refer to forms now called *Lopha* or *Texigryphaea*.
- Panopaea?* sp.**
 HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2).
- Pecten occidentalis***
 See *Neitheia occidentalis*.
- Pecten (Neitheia) texanus***
 See *Neitheia texana*.
- Pecten* sp., *Pecten (Neitheia)* sp.**
 See *Neitheia* sp.

***Pholadomya* sp.**

SCOTT, 1970a, p. 1240, as *Pholadomya*? sp., Tucumcari Formation, Tucumcari area; SCOTT, 1974, pp. 323, 325, Tucumcari Formation, San Jon section (Loc. 25).

***Pinna comancheana* Cragin, 1894**

CUMMINS, 1892, p. 208, as *Pinna* sp., Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; MARCOU, 1892, p. 374, as *Pinna* sp., questions occurrence in Cretaceous rocks; ANONYMOUS, 1892, p. 311, as *Pinna* sp., quoted from Cummins (1892); CRAGIN, 1894, p. 3, Fredericksburg division, Tucumcari district, assigns *Pinna* sp. collected by Cummins to *P. comancheana*; HILL, 1895, p. 230, upper Tucumcari beds, Tucumcari region; CRAIGIN, 1895, p. 370, Kiowa-equivalent shales (= Tucumcari shales), Tucumcari district; STANTON & VAUGHAN, 1896, p. 25, quoted from Hill (1895); BULLARD, 1928, p. 95, Purgatoire Formation, Tucumcari region; DARTON, 1928, p. 39, Purgatoire Formation, vicinity of Tucumcari; ADKINS, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; BRAND, 1953, p. 15, Tucumcari Shale Member of Purgatoire Formation, Quay County; BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area; JACKA & BRAND, 1973, p. 48, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin.

***Pinna* sp.**

CUMMINS, 1892, MARCOU, 1892, ANONYMOUS, 1892, see *Pinna comancheana*; TRAUGER ET AL., 1972, p. 41, as *Pinna* sp. (?), Tucumcari Shale, along NM-88, 4.2 mi (6.7 km) north of its junction with NM-231 (Loc. 39), stated to be probably *P. petrina* or *P. comancheanus*.

***Plicatula incongrua* Conrad, 1857**

SCOTT, 1974, pp. 322, 328, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35).

***Plicatula* cf. *P. incongrua* Conrad, 1857**

ASH & CLEBSCH, 1961, p. D-139, Tucumcari Shale, 11 mi (17.6 km) north of Tatum (Loc. 29).

***Plicatula* sp.**

HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2); HILL, 1895, p. 230, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, quoted from Hill (1895); BULLARD, 1928, p. 95, Purgatoire Formation, Tucumcari region; DARTON, 1928, p. 39, Purgatoire Formation, vicinity of Tucumcari; ADKINS, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; BRAND, 1953, p. 15, Tucumcari Shale Member of Purgatoire Formation, Quay County; ASH & CLEBSCH, 1961, p. D-139, Tucumcari Shale, east-central New Mexico; BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area; JACKA & BRAND, 1973, p. 47, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin. NOTE: Based on Scott's (1974) identification of *P. incongrua* from the Tucumcari Shale, it is probable that these citations of *P. sp.* refer to that species.

***Protocardia multistriata* (Shumard, 1853)**

HILL, 1893, p. 24, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2); HILL, 1895, pp. 230–231, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, quoted from Hill (1895); DARTON, 1928, p. 39, Purgatoire Formation, vicinity of Tucumcari; SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

***Protocardia texana* (Conrad, 1857)**

CUMMINS, 1892, pp. 208–209, as *Cardium hillanum*, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; MARCOU, 1892, p. 374, as *C. hillanum*, questions Cretaceous occurrence in Tucumcari area; ANONYMOUS, 1892, p. 311, as *C. hillanum*, Cretaceous, Tucumcari Mountain (Loc. 2); MARCOU, 1893b, p. 358, as *C. hillanum*, doubts Cummins' (1892) identification; HILL, 1895, p. 230, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, quoted from Hill (1895); DARTON, 1928, pp. 39, 290, Purgatoire Formation, vicinity of Tucumcari, and Cuervo Hill (Loc. 11); SCOTT, 1970a, p. 1228, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36); BRAND & MATTOX, 1972, p. 101, Tucumcari Shale, Tucumcari area, and San Jon section (Loc. 25); JACKA & BRAND, 1973, p. 47, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; SCOTT, 1974,

pp. 323, 328, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35) and east side of Liberty Mesa (Loc. 36).

***Protocardia* sp.**

BULLARD, 1928, p. 95, Purgatoire Formation, Tucumcari region; ADKINS, 1932, p. 281, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; BRAND, 1953, p. 15, Tucumcari Shale Member of Purgatoire Formation, Quay County.

Roudairia quadrans

See *Veniella quadrans*.

***Scabrotrigonia emoryi* (Conrad, 1857)**

MARCOU, 1855a, p. 44, as "trigonia," Jurassic, Tucumcari area; BLAKE, 1856a, p. 81, as *Trigonia* sp., quoted from Marcou (1855a); BLAKE, 1856b, p. 137, as *Trigonia* sp., Lower Cretaceous, east of Tucumcari Mountain; MARCOU, 1858a, p. 20, as *Trigonia* sp., Jurassic, Tucumcari area; DANA, 1858, p. 330, as *Trigonia* sp., Cretaceous, Llano Estacado; CUMMINS, 1892, pp. 208–209, as *Trigonia emoryi*, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; MARCOU, 1892, p. 374, as *T. emoryi*, questions Cretaceous occurrence in Tucumcari area; ANONYMOUS, 1892, p. 311, as *T. emoryi*, quoted from Cummins (1892); CUMMINS, 1893, p. 283, as *T. emoryi*, Cretaceous, Tucumcari Mountain (Loc. 2); MARCOU, 1893b, p. 358, as *T. emoryi*, quoted from Cummins (1892), doubts Cretaceous age; HILL, 1893, p. 24, as *T. emoryi*, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2); HILL, 1895, p. 230, as *T. emoryi*, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, as *T. emoryi*, quoted from Hill (1895); BULLARD, 1928, p. 95, as *T. emoryi*, Purgatoire Formation, Tucumcari region; DARTON, 1928, pp. 39, 290, as *T. emoryi* [sic], Purgatoire Formation, vicinity of Tucumcari, and Cuervo Hill (Loc. 11); ADKINS, 1932, p. 281, as *T. emoryi*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, as *T. emoryi*, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; BRAND, 1953, p. 15, as *T. emoryi*, Tucumcari Shale Member of Purgatoire Formation, Quay County; SCOTT, 1969b, p. 26, upper Tucumcari Formation, northeast New Mexico; SCOTT, 1970a, p. 1228, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36); BRAND & MATTOX, 1972, pp. 101–103, as *Trigonia emoryi*, Tucumcari Shale, Tucumcari area and San Jon section (Loc. 25); JACKA & BRAND, 1973, p. 47, as *T. emoryi*, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; SCOTT, 1974, pp. 323, 328, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), east side of Liberty Mesa (Loc. 36); GAGE & ASQUITH, 1977, p. 8, as *Trigonia emoryi*, Mesa Rica Sandstone, Tucumcari area.

***Stearnsia* sp.**

SCOTT, 1985 (written comm.), Tucumcari Formation, San Jon section (Loc. 25).

***Syncyclonema inconspicuus* (Cragin, 1894)**

SCOTT, 1974, p. 323, Tucumcari Formation, San Jon section (Loc. 25).

Tapes belviderensis

See *Flaventia belviderensis*.

Texigryphaea corrugata

See *Texigryphaea pitcheri*.

***Texigryphaea mucronata* (Gabb, 1869)**

BRAND & MATTOX, 1972, p. 101, as *Gryphaea marcoui*, Tucumcari Shale, Tucumcari area; JACKA & BRAND, 1973, p. 47, as *G. marcoui*, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin.

***Texigryphaea pitcheri* (Morton, 1834)**

NOTE: Confusion and controversy have plagued the question of the identity and relationships of *T. pitcheri* (called for many decades *Gryphaea corrugata*) and *T. tumucarii* (considered a separate species by some authors but a synonym of *G. corrugata* or *G. pitcheri* by others). It is difficult in some cases to determine which form an author was referring to under the name of *Gryphaea pitcheri* or *G. corrugata*. References to *T. pitcheri* included here are generally those in which that species (or *G. corrugata*) is listed together with, but separately from *G. tumucarii* (see text for additional discussion). CUMMINS, 1892, pp. 208–209, as *Gryphaea pitcheri*, Tucumcari beds, vicinity

of Tucumcari and Pyramid Mountains; MARCOU, 1892, pp. 374–375, as *G. pitcheri*, denies Cummins' (1892) report of its presence in the Tucumcari area; ANONYMOUS, 1892, p. 311, as *G. pitcheri*, quoted from Cummins (1892); CUMMINS, 1893, p. 283, as *G. pitcheri*, Cretaceous, Tucumcari Mountain (Loc. 2); HILL, 1895, p. 230, as *G. pitcheri*, upper Tucumcari beds, Tucumcari region; STANTON & VAUGHAN, 1896, p. 25, as *G. pitcheri*, quoted from Hill (1895); HILL & VAUGHAN, 1898, pp. 34–35, refers *G. pitcheri* to *G. corrugata*; BULLARD, 1928, p. 95, as *G. corrugata*, Purgatoire Formation, Tucumcari region; DARTON, 1928, pp. 39, 302, as *G. pitcheri* and *G. corrugata*, Purgatoire Formation, vicinity of Tucumcari and west face of Mesa Rica (Loc. 8); STANTON, 1928, p. 407, as *G. corrugata*, Washita, eastern New Mexico; ADKINS, 1932, p. 281, as *G. corrugata*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, as *G. corrugata*, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; STANTON, 1947, taxon-distribution chart, as *G. corrugata*, Purgatoire Formation, Tucumcari Mountain (Loc. 2) and northeast of entrance to Apache Canyon (Loc. 14); BRAND, 1953, p. 15, as *G. corrugata*, Tucumcari Shale Member of Purgatoire Formation, Quay County; ASH & CLEBSCH, 1961, p. D-139, as *G. corrugata*, Tucumcari Shale, 11 mi (17.6 km) north of Tatum (Loc. 29); DEFORD, 1972, pp. 67–68, 70, discusses *T. corrugata*–*T. tumucarii* problems; BRAND & MATTOX, 1972, pp. 101–102, as *G. corrugata*, Tucumcari Shale, Tucumcari area and San Jon section (Loc. 25); JACKA & BRAND, 1973, p. 47, as *G. eorugata* [sic], Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; FAY, 1975, p. 46, suppressed *G. corrugata* Say as a *nomen nudum*; reinstated *T. pitcheri*.

**Texigryphaea tumucarii* (Marcou, 1855)

NOTE: The status of *T. tumucarii* as a species or variety distinct from *T. pitcheri* has been debated since Marcou first described it. References listed here include all that refer to Marcou's Pyramid Mountain specimens, and later references in which *T. tumucarii* is cited separately from *T. pitcheri* or *T. corrugata* (see text for additional discussion). MARCOU, 1855a, p. 44, as *Gryphaea tumucarii*, Jurassic Tucumcari area; MARCOU, 1855b, p. 880, pl. 21, figs. 1–2 (as *G. dilatata*), pl. 21, fig. 3 (as *G. dilatata* var. *tumucarii*), Jurassic, Pyramid Mountain (Loc. 1); BLAKE, 1856a, p. 25, as *G. tumucarii* of Marcou, probably a new species or variety of *G. pitcheri*, Jurassic?, Pyramid Mountain; pp. 79, 81, Cretaceous of Pyramid Mountain and Llano Estacado; BLAKE, 1856b, p. 137, as *Ostrea dilatata*, Jurassic, Pyramid Mountain; BLAKE, 1856c, p. 386, as *G. tumucarii*, Cretaceous, Pyramid Mountain; HALL, 1856, pp. 99–100, pl. 1, figs. 1–6, as *G. pitcheri*, Cretaceous, Pyramid Mountain; Marcou, 1861a, pointed out that Hall's pl. 1, fig. 10 was a copy of Marcou's (1855b) pl. 21, fig. 1b (=pl. 4, fig. 1b of Marcou, 1858a), which represented *G. tumucarii*, although Hall had mislabeled it *G. pitcheri* var. *navia*; MEEK & HAYDEN, 1857, p. 132, as *G. pitcheri*, Cretaceous Unit 2, Pyramid Mountain; HALL, 1857a, pp. 135–136, as *G. pitcheri*, Nebraska Cretaceous Units 2 and 3 equivalent, Pyramid Mountain; HALL, 1857b, pp. 84–85, as *G. pitcheri*, Nebraska Cretaceous Units 2 and 3 equivalent, Pyramid Mountain; MARCOU, 1858a, pp. 18–20, 43, pl. 4, figs. 1, 1a–b, 2–3, as *G. dilatata* and *G. dilatata* var. *tumucarii*, Jurassic, Pyramid Mountain and bluffs surrounding Plaza Larga, in the bed of Fossil Creek, at the Big and Little Tucumcari Mountains, Monte Revuelto, and the Llano Estacado; MARCOU, 1858b, pp. 4–7, rejects Meek & Hayden's opinion that *G. dilatata* is *G. pitcheri*; DANA, 1858, pp. 330–331, as *G. pitcheri*, Cretaceous, Llano Estacado; SHUMARD, 1860, p. 587, as *G. pitcheri*, Nebraska Cretaceous Unit 3 equivalent, Pyramid Mountain; ANONYMOUS, 1861, p. 127, as *G. dilatata* of Marcou, Cretaceous Units 2 & 3, [Tucumcari area]; MARCOU, 1861a, pp. 93–97, as *G. tumucarii*, Jurassic, Pyramid Mountain; MARCOU, 1861b, p. 548, as *G. dilatata* var. *tumucarii*, Jurassic, Pyramid Mountain; GABB, 1861, p. 549, as *G. pitcheri*, Cretaceous, [Pyramid Mountain]; MEEK, 1861, p. 280, as *G. tumucarii* of Marcou, Cretaceous, [Tucumcari area]; GABB, 1862, pp. 21–22, as *G. pitcheri*, Cretaceous, [Pyramid Mountain]; HILL, 1888, pp. 172–173, as *G. dilatata*, Jurassic, "Tucumcari Mountains"; MARCOU, 1889a, pp. 157, 161–163, 217, 219, as *G. dilatata* var. *tumucarii* and *G. tumucarii*, Jurassic, Pyramid Mountain; MARCOU, 1890, p. 317, as *G. dilatata* var. *tumucarii*, Jurassic, Pyramid Mountain; CUMMINS, 1892, pp. 202, 204, 206–209, as *G. dilatata* var. *tumucarii*, Tucumcari beds, vicinity of Tucumcari and Pyramid Mountains; MARCOU, 1892, pp. 373–375, as *G. dilatata* var. *tumucarii*, Jurassic, Tucumcari area; ANONYMOUS, 1892, pp. 311, 313, as *G. dilatata* var. *tumucarii*, quoted from Cummins (1892); HILL, 1892, p. 394, as *G. dilatata* of Marcou, Lower Cretaceous, Mesa Tucumcari (Loc. 2); CUMMINS, 1893, p. 283, as *G. dilatata* var. *tumucarii*, Cretaceous, Tucumcari Mountain (Loc. 2); MARCOU, 1893a, pp. 213–214, Jurassic, Tucumcari area; MARCOU, 1893b, pp. 358–359, as *G. dilatata* var. *tumucarii*, Jurassic, Tucumcari area,

rejects Cummins' (1892) conclusion that it is Cretaceous; HILL, 1893, pp. 23–25, as *G. dilatata* and *Ostrea (Gryphaea) dilatata*, Unit 4 (Washita division), Tucumcari Mesa (Loc. 2); MARCOU, 1894, pp. 102–103, as *G. dilatata* var. *tumucarii* and *G. tumucarii*, Jurassic, Pyramid Mountain (Loc. 1); HILL, 1895, pp. 230, 232, as *G. dilatata* var. *tumucarii*, Upper Tucumcari beds, Tucumcari region; CRAGIN, 1895, p. 382, as *G. tumucarii*, Kiowa shale equivalent (Tucumcari shales), Tucumcari Mountain (Loc. 2); STANTON & VAUGHAN, 1896, p. 25, as *G. dilatata* var. *tumucarii*, quoted from Hill (1895); MARCOU, 1897, pp. 205, 207, 208, 210, 212, as *G. tumucarii*, Jurassic, Pyramid Mountain (Loc. 1); HILL & VAUGHAN, 1898, pp. 13–23, 36–37, 39–42, 46, 56–57, 65; pl. 13, figs. 1–5, pl. 14, figs. 1–2, pl. 16, figs. 1–3 (copies of Marcou, 1858a, pl. 4, figs. 1, 1a, 3) as *G. corrugata* var. *tumucarii*; pl. 17, fig. 5 (copy of Marcou, 1858a, pl. 4, fig. 2), as *G. dilatata* var. *tumucarii*; pl. 15, figs. 1–7 (copies of Hall, 1856, pl. 1, figs. 1–6, 10), as *G. corrugata*, Lower Cretaceous, Tucumcari area; BAKER, 1920, pp. 120–121, as *G. tumucarii*, upper Tucumcari beds, Tucumcari Mountain (Loc. 2) and 11.5 mi (18.4 km) west of Tucumcari (Loc. 6); ADKINS, 1927, pp. 56–57, pl. 4, fig. 1 (said to be holotype of *G. tumucarii*; the specimen figured by Marcou, 1858a, as pl. 4, fig. 3), [Lower Cretaceous], Tucumcari area; BULLARD, 1928, p. 95, as *G. corrugata* var. *tumucarii*, Purgatoire Formation, Tucumcari Mountain (Loc. 2) and Tucumcari region; DARTON, 1928, p. 39, as *G. dilatata* var. *tumucarii*, Purgatoire Formation, vicinity of Tucumcari; STANTON, 1928, p. 407, as *G. tumucarii*, Washita, eastern New Mexico; ADKINS, 1928, p. 107, pl. 6, fig. 1 (of holotype: = pl. 4, fig. 1 of Adkins, 1927, and pl. 4, fig. 3 of Marcou, 1858a), as *G. tumucarii*, Kiamichi and Duck Creek equivalents, near Tucumcari; ADKINS, 1932, p. 281, as *G. tumucarii*, Purgatoire Formation, Tucumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, as *G. corrugata* var. *tumucarii*, Tucumcari Shale Member of Purgatoire Formation, northwest Quay County; STANTON, 1947, taxon-distribution chart, pl. 14, fig. 4, pl. 15, figs. 13–14, as *G. corrugata tumucarii*, Purgatoire Formation, Tucumcari Mountain (Loc. 2), northeast of entrance to Apache Canyon (Loc. 14), and large mesa northwest of Fort Bascom site (Loc. 15); BRAND, 1953, p. 15, as *G. corrugata* var. *tumucarii*, Tucumcari Shale Member of Purgatoire Formation, Quay County; STENZEL, 1959, pp. 21, 28, as *G. (Texigryphaea) tumucarii*, Albian of New Mexico; SCOTT, 1970a, pp. 1228, 1233–1234, 1236, as *G. tumucarii*, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), and east side of Liberty Mesa (Loc. 36); DEFORD, 1972, pp. 67–68, 70, unnumbered figure (copy of Hill & Stanton, 1898, pl. 14, figs. 1, 2), Tucumcari Shale, Tucumcari area; BRAND & MATTOX, 1972, pp. 101–102, as *G. tumucarii*, Tucumcari Shale, Tucumcari area and San Jon section (Loc. 25); TRAUGER ET AL., 1972, pp. 36, 40, as *G. tumucarii*, Tucumcari Shale, San Jon section (Loc. 25) and along NM-88, 4.2 mi (6.7 km) north of its intersection with NM-231 (Loc. 39); JACKA & BRAND, 1972, p. 106, as *G. tumucarii*, Tucumcari Shale, along Atarque Creek (Loc. 37); JACKA & BRAND, 1973, p. 47, as *G. tumucarii*, Tucumcari Shale and Mesa Rica Sandstone, Tucumcari basin; SCOTT, 1974, p. 328, Tucumcari Formation, [San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35) and east side of Liberty Mesa (Loc. 36)]; FAY, 1975, pp. 54–55, figs. 23, 24 (the holotype, originally illustrated by Marcou, 1855b, pl. 21, fig. 3), Tucumcari Shale, Tucumcari Mountain [actually Pyramid Mountain]; KAUFFMAN, 1977, pp. 227, 229, pl. 2, figs. 10, 12, Washita Group equivalent, Mesa Tucumcari. TYPES: Holotype, British Museum, BM 12676 (Adkins, 1927, 1928), now numbered LL 1493 (fide Fay, 1975, p. 55).

Texigryphaea washitaensis (Hill and Vaughan, 1898)

FAY, 1975, p. 49, Tucumcari Shale [Tucumcari area?].

Texigryphaea sp.

GARRETT, 1920, p. 76, as *Gryphaea* sp., Purgatoire Formation, Tucumcari Mountain (Loc. 2); TRAUGER & BUSHMAN, 1964, p. 26, as *Gryphaea* sp., Tucumcari Shale, north side of Mesa Quemado (Loc. 33); SCOTT, 1969a, p. 25, as *Gryphaea* sp., Tucumcari Formation, east-central New Mexico; TRAUGER ET AL., 1972, pp. 38, 40, as *Gryphaea* sp., Tucumcari Shale, along NM-88, 3.9 mi (6.2 km) north of its junction with NM-231 (Loc. 40), and in basal sandstone of Ogallala Formation (reworked from Tucumcari Shale), along NM-88, 2.0 mi (3.2 km) north of its junction with NM-231 (Loc. 38); KELLEY & KELLEY, 1972, p. 47, as *Gryphaea* sp., Tucumcari Shale, along I-40, 7.9 mi (12.6 km) west of Tucumcari (Loc. 42); BRAND & MATTOX, 1972, p. 101, as *Gryphaea* sp., Tucumcari Shale, Tucumcari area; SCOTT, 1974, pp. 322–323, Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35) and east side of Liberty Mesa (Loc. 36).

Trachycardium sp.

SCOTT, 1985 (written comm.), Tukumcari Formation, San Jon section (Loc. 25).

Trigonia emoryi

See *Scabrotrigonia emoryi*.

Trigonia sp.

See *Scabrotrigonia emoryi*.

Veniella quadrans (Cragin, 1893)

HILL, 1895, p. 230, as *Roudaria*(?) [sic] *quadrans*, upper Tukumcari beds, Tukumcari region; STANTON & VAUGHAN, 1896, p. 25, as *Roudairia*(?) *quadrans*, quoted from Hill (1895).

Mollusca: Ammonoidea**Adkinsites belknapi (Marcou, 1858a)**

MARCOU, 1894, p. 102, as *Ammonites belknapii*, Jurassic, Pyramid Mountain (Loc. 1). NOTE: Young (1966, p. 119) did not cite this species from east-central New Mexico. *Adkinsites bravoensis*, a closely related species, does occur there, and it is possible that Marcou's report refers to that species.

Adkinsites bravoensis (Böse, 1910)

YOUNG, 1966, pp. 49, 119–124, Tukumcari Formation, near Rogers, Roosevelt County (Locs. 55, 56).

Adkinsites imlayi Young, 1966

YOUNG, 1966, pp. 49, 127–130, Tukumcari Formation, near Rogers, Roosevelt County (Locs. 55, 56).

Ammonites belknapii

See *Adkinsites belknapi*.

Ammonites leonensis

See *Mortoniceras leonensis*.

Ammonites shumardi

See *Mortoniceras shumardi*.

Ammonites sp.

CUMMINS, 1892, p. 208, Tukumcari beds, vicinity of Tukumcari and Pyramid Mountains; MARCOU, 1892, p. 374, quoted from Cummins (1892); ANONYMOUS, 1892, p. 311, quoted from Cummins (1892). NOTE: Assignment to a presently recognized genus must await examination of the specimens, assuming they are available.

Craginites aff. C. serratescens (Cragin, 1893)

BRAND & MATTOX, 1972, p. 101, Tukumcari Shale, Tukumcari area; JACKA & BRAND, 1973, p. 48, Tukumcari Shale and Mesa Rica Sandstone, Tukumcari basin.

Craginites sp.

TRAUGER ET AL., 1972, p. 36, Tukumcari Shale, San Jon section (Loc. 25); BRAND & MATTOX, 1972, pp. 99, 103, Tukumcari Shale, San Jon section (Loc. 25).

Eopachydiscus brazoense

See *Eopachydiscus marcianus*.

Eopachydiscus laevicaniculatum (Roemer in Lasswitz, 1904)

BRAND & MATTOX, 1972, p. 103, Tukumcari Shale, San Jon section (Loc. 25).

Eopachydiscus aff. E. laevicaniculatum (Roemer in Lasswitz, 1904)

TRAUGER ET AL., 1972, p. 36, Tukumcari Shale, San Jon section (Loc. 25); BRAND & MATTOX, 1972, p. 101, Tukumcari Shale, Tukumcari area; JACKA & BRAND, 1973, p. 48, Tukumcari Shale and Mesa Rica Sandstone, Tukumcari basin.

Eopachydiscus marcianus (Shumard, 1854)

BRAND & MATTOX, 1972, p. 101, as *E. brazoense* [sic], Tukumcari Shale,

Tukumcari area; COBBAN, 1985, p. 1, Mesa Rica Sandstone, Tukumcari area.

Mortoniceras equidistans (Cragin, 1893)

STANTON, 1928, p. 407, as *Pervinquieria trinodosa*, Washita, eastern New Mexico; TRAUGER ET AL., 1972, p. 36, as *P. equidistans*, Tukumcari Shale, San Jon section (Loc. 25); BRAND & MATTOX, 1972, pp. 101, 103, as *P. equidistans*, Tukumcari Shale, Tukumcari area and San Jon section (Loc. 25); JACKA & BRAND, 1973, p. 48, as *P. equidistans*, Tukumcari Shale and Mesa Rica Sandstone, Tukumcari basin; COBBAN, 1985, pp. 1–4, Purgatoire Formation and Mesa Rica Sandstone, Tukumcari area.

Mortoniceras aff. M. equidistans (Cragin, 1893)

BRAND & MATTOX, 1972, p. 101, as *Pervinquieria* aff. *equidistans*, Tukumcari Shale, Tukumcari area.

Mortoniceras leonensis (Conrad, 1857)

HILL, 1893, p. 24, as *Ammonites leonensis*, Unit 4 (Washita division), Tukumcari Mesa (Loc. 2); HILL, 1895, pp. 230, 233, as *A. leonensis*, upper Tukumcari beds, Tukumcari region; STANTON & VAUGHAN, 1896, p. 25, as *A. leonensis*, quoted from Hill (1895); DARTON, 1928, p. 39, as *A. leonensis*, Purgatoire Formation, vicinity of Tukumcari; BULLARD, 1928, p. 95, as *Pervinquieria leonensis*, Purgatoire Formation, Tukumcari area; ADKINS, 1932, p. 281, as *P. "leonensis"*, Purgatoire Formation, Tukumcari Mountain (Loc. 2); DOBROVOLNY ET AL., 1946, as *P. leonensis*, Tukumcari Shale Member of Purgatoire Formation, northwest Quay County; BRAND, 1953, p. 15, as *P. leonensis*, Tukumcari Shale Member of Purgatoire Formation, Quay County.

Mortoniceras shumardi (Marcou, 1858)

MARCOU, 1897, p. 206, as *Ammonites shumardi* and *Schloenbachia shumardi*, Jurassic or Cretaceous, Tukumcari area; HILL & VAUGHAN, 1898, pp. 19, 21, as *A. shumardi* and *S. shumardi*, Tukumcari beds, Tukumcari area; ADKINS, 1932, p. 281, *Pervinquieria shumardi*, Purgatoire Formation, Tukumcari Mountain (Loc. 2).

Mortoniceras ?vespertinum (Morton, 1834)

DARTON, 1928, p. 290, as *Schloenbachia vespertina*?, Purgatoire Formation, Cuervo Hill (Loc. 11).

Mortoniceras sp.

JACKA & BRAND, 1972, p. 106, as *Pervinquieria* sp., Tukumcari Shale, along Atarque Creek (Loc. 37).

Pervinquieria equidistans

See *Mortoniceras equidistans*.

Pervinquieria aff. P. equidistans

See *Mortoniceras* aff. *M. equidistans*.

Pervinquieria leonensis

See *Mortoniceras leonensis*.

Pervinquieria shumardi

See *Mortoniceras shumardi*.

Pervinquieria trinodosa

See *Mortoniceras equidistans*.

Pervinquieria sp.

See *Mortoniceras* sp.

Schloenbachia shumardi

See *Mortoniceras shumardi*.

Schloenbachia vespertina?

See *Mortoniceras ?vespertinum*.

Arthropoda: Cirripedia**Lithoglyptid barnacles**

SCOTT, 1974, pp. 323 and 328, as "barnacle borings" and "lithoglyptid

barnacles," Tucumcari Formation, San Jon section (Loc. 25), Tucumcari Mountain (Loc. 35), and east side of Liberty Mesa (Loc. 36).

Vertebrata

Shark teeth

GAGE & ASQUITH, 1977, p. 8, Mesa Rica Sandstone, Tucumcari area.

Ichnofossils

Ophiomorpha sp.

GAGE & ASQUITH, 1977, pp. 6–7, fig. 8, Mesa Rica Sandstone, Tucumcari area.

Rhizocorallum sp.

GAGE & ASQUITH, 1977, pp. 6–7, fig. 7, Mesa Rica Sandstone, Tucumcari area.

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APPENDIX: LOCALITIES

Localities from which fossils of the Tucumcari Shale, Mesa Rica Sandstone and Pajarito Shale have been reported are listed here, together with the papers in which these localities were cited. Unless otherwise indicated, the fossiliferous zone present at these localities is the Tucumcari Shale and/or the basal Mesa Rica Sandstone. Localities that are not referenced represent unpublished sites from which we have made collections. The locality numbers are keyed to Figure 2 and to the annotated catalog of fossils presented earlier.

1. Pyramid Mountain, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 19, T9N, R29E, Quay County (Marcou, 1858a; Kues and Kietzke, 1985).
2. Tucumcari Mountain, SW $\frac{1}{4}$ sec. 31, T11N, R31E, Quay County (Cummins, 1892; Hill, 1893; Stanton, 1905; Baker, 1920; Bullard, 1928; Darton, 1928; Stanton, 1947, as USGS Mesozoic Locality 18511).
3. 4 mi (6.4 km) west of Big Tucumcari Mountain, Quay County (Cummins, 1892).
4. About 10 mi (16 km) northwest of Tucumcari [probably along north side of Mesa Rica], Quay or San Miguel County (Stanton, 1905).
5. North side of Canadian River, 15 mi (24 km) northwest of Tucumcari [south side of Carpenter Mesa?], San Miguel County (Stanton, 1905).
6. Bluff on north side of a small arroyo, 11.5 mi (18.4 km) west of Tucumcari [probably north side of Pajarito Creek, along south side of Mesa Rica], Quay County (Baker, 1920).
7. Cliff about 3 mi (4.8 km) south of Montoya [probably the west end of Palomas Mesa, sec. 26, T10N, R27E], Quay County (Darton, 1928).
8. West face of Mesa Rica, 10 mi (16 km) east of Isadore post office [Johnson Rincon, T12N, R28E (?)], San Miguel County (Darton, 1928).
9. West slope of the plateau about a mile (1.6 km) west of Ima post office [W $\frac{1}{2}$ sec. 15 or NW $\frac{1}{4}$ sec. 22, T8N, R27E], Quay County (Darton, 1928).
10. 13 mi (20.8 km) southeast of Portales [T3S, R37E], Roosevelt County (Darton, 1928).
11. Top of Cuervo Hill, about 20 mi (32 km) northeast of Santa Rosa [sec. 33, T11N and sec. 4, T10N, R23E (projected)], Guadalupe County (Darton, 1928; Gorman and Robeck, 1946).
12. West side of mesa on point east of Arroyo de la Laguna, USGS Mesozoic Locality 18512 [exact locality undetermined], Quay County (Stanton, 1947).
13. Monte Revuelto, on south side of point at head of Canyon Bonito, USGS Mesozoic Locality 18513 [probably in Bonita fault-zone area in Apache Canyon], T8N, R33E, Quay County (Stanton, 1947).
14. Face of bluff of Llano Estacado, northeast of entrance to Apache Canyon, USGS Mesozoic Locality 18514 [probably E $\frac{1}{2}$ sec. 5, T8N, R33E], Quay County (Stanton, 1947).
15. Mesa northwest of Fort Bascom, USGS Mesozoic Locality 18515 [large mesa north of Canadian River, about 3 mi (4.8 km) northwest of confluence of Pajarito Creek and the Canadian River], San Miguel County (Stanton, 1947).
16. Canyon Jonda, Mesa Rica, USGS Mesozoic Locality 18516 [Hondo Canyon, west side of Liberty Mesa, probably NW $\frac{1}{4}$ T11N, R29E], Quay County (Stanton, 1947).
17. Canyon, 11 mi (17.6 km) west of Ragland [probably Long Canyon, W $\frac{1}{2}$ sec. 18, T7N, R29E], Quay County (Smith, 1951).
18. Roadcut, NM-156, 1 mi (1.6 km) west of Ima [W $\frac{1}{2}$ sec. 15, T8N, R27E], Quay County (Smith, 1951).
19. West-facing escarpment of Mesa Redonda, about 2 mi (3.2 km) north of Quay on NM-18 and about 3 mi (4.8 km) east of the highway [NE $\frac{1}{4}$ sec. 36, T9N, R30E], Quay County (Smith, 1951).
20. Roadcut along a private road about 6 mi (9.6 km) south of Montoya [probably west side of Sunflower Canyon, S $\frac{1}{2}$ sec. 9, T9N, R27E, along north side of Luciano Mesa], Quay County (Smith, 1951).
21. In an escarpment 18.75 mi (30 km) west and 6 mi (9.6 km) north of Ragland [about 1 mi (1.6 km) west of Ima, near or at Localities 9 and 18], Quay County (Brand, 1953).
22. Outlier exposed in the west pasture of the Briscoe Ranch, directly west of the ranchhouse, 10 mi (16 km) south and 4.75 mi (7.6 km) west of Tucumcari, SW $\frac{1}{4}$ sec. 36, T10N, R29E [small outlier just east of Mesa Quemado], Quay County (Brooks, 1959).
23. North-facing railroad right-of-way cut, 8.7 mi (13.9 km) west of Tucumcari, 400 yds north of US-66, NE $\frac{1}{4}$ sec. 4, T10N, R29E [a short distance north of modern I-40], Quay County (Brooks, 1959).
24. Near north end of Saddleback Mesa, 5.5 mi (8.8 km) west of Quay, NE $\frac{1}{4}$ sec. 3, T8N, R29E, Quay County (Brooks, 1959).
25. Roadcut along NM-39 about 9 mi (14.4 km) south of San Jon [E $\frac{1}{2}$ sec. 20, T9N, R34E], and Day 1, Stop 5, mile 161.45 of Trauger et al. (1972), Quay County (Brooks, 1959; Scott, 1970a; Brand and Mattox, 1972; Jacka and Brand, 1973).
26. Spike Canyon, 4.9 mi (7.8 km) north and 3.1 mi (5.0 km) east of Quay, along north side of Mesa Redonda, SE $\frac{1}{4}$ sec. 19, T9N, R31E, Quay County (Brooks, 1959).
27. Near Dripping Springs, 5.25 mi (8.4 km) east and 1.5 mi (2.4 km) north of Quay, along south side of Mesa Redonda, NE $\frac{1}{4}$ sec. 4, T8N, R31E, Quay County (Brooks, 1959).
28. Roadcut on US-66, 8.8 mi (14.1 km) west of Tucumcari, SW $\frac{1}{4}$ sec. 4, T10N, R29E, Quay County (Brooks, 1959).
29. About 2 mi (3.2 km) west of NM-18 and about 11 mi (17.6 km) north of Tatum, sec. 32, T10S, R34E, Lea County (Ash and Clebsch, 1961).
30. 300 to 400 ft (90 to 120 m) east of entrance to Metropolitan Park [about 4 mi (6.4 km) southwest of Tucumcari], sec. 30, T11N, R30E, Quay County (Trauger and Bushman, 1964).
31. North-central part of sec. 9, T10N, R29E, Quay County (Trauger and Bushman, 1964).
32. NW $\frac{1}{4}$ sec. 5, T11N, R30E [east side of Liberty Mesa, in Dickie Canyon], Quay County (Trauger and Bushman, 1964).
33. Summit of a knoll, NE $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 10, T10N, R29E [north side of Mesa Quemado], Quay County (Trauger and Bushman, 1964).
34. In escarpment on promontory, SW $\frac{1}{4}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5, T11N, R30E [east side of Liberty Mesa, in Dickie Canyon], Quay County (Trauger and Bushman, 1964).
35. South face of Tucumcari Mountain, SW $\frac{1}{4}$ sec. 31, T11N, R31E, Quay County (Scott, 1970a).
36. East scarp of Liberty Mesa, about 5 mi (8 km) northwest of Tucumcari, secs. 5 and 6, T11N, R30E, Quay County (Scott, 1970a).
37. Along Atarque Creek, about 2 mi (3.2 km) north of the site of Atarque, San Miguel County (Trauger et al., 1972: Day 1, Stop 2, mile 50.7; Jacka and Brand, 1972).
38. Along NM-88, 2.0 mi (3.2 km) north of its junction with NM-231, Quay County (Trauger et al., 1972: Day 1, Stop 6, mile 176.0).
39. Along NM-88, 4.2 mi (6.7 km) north of its junction with NM-231, Quay County (Trauger et al., 1972: Day 1, Stop 7, mile 178.15).
40. South of NM-88, 3.9 mi (6.2 km) north of its junction with NM-231, Quay County (Trauger et al., 1972: Day 1, mile 177.9).
41. Roadbank along NM-39, 8.2 mi (13.1 km) east of Mosquero, Harding County (Trauger et al., 1972: Day 1, mile 86.50), shale possibly correlative with Pajarito Shale.
42. Roadcut along I-40 and hillside just beyond east end of cut, 7.9 mi (12.6 km) west of the center of Tucumcari, Quay County (Kelley and Kelley, 1972: Day 2, mile 8.0).
43. NW $\frac{1}{4}$ sec. 27, T9N, R33E, Quay County (USGS collection locality).
44. Sec. 18, T8N, R33E, Quay County (USGS collection locality).
45. Sec. 33, T9N, R33E, Quay County (USGS collection locality).
46. Sec. 13, T9N, R33E, Quay County (USGS collection locality).
47. Sec. 18, T9N, R34E, Quay County (USGS collection locality).
48. Sec. 16, T9N, R34E, Quay County (USGS collection locality).
49. South side of Mesa Quemado, NE $\frac{1}{4}$, NE $\frac{1}{4}$ sec. 10, T9N, R29E, Quay County (Kues and Kietzke, 1985).
50. Small outcrop on south side of unpaved road, 4.3 mi (6.9 km) west of NM-18, NE $\frac{1}{4}$ SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 1, T9N, R29E, Quay County (Kues and Kietzke, 1985).
51. Center of NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 8, T9N, R29E, southwest of Mesa Quemado, Quay County (Kues and Kietzke, 1985).
52. Bull Canyon, SE $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 23, T9N, R26E, Guadalupe County.
53. Bull Canyon, NW $\frac{1}{4}$ NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 24, T9N, R26E, Guadalupe County.
54. Apache Canyon, NW $\frac{1}{4}$ NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 3, T8N, R33E, Quay County.
55. Sec. 30, T3S, R36E, near Rogers, USGS Mesozoic Localities 13846, 14349, Roosevelt County (Young, 1966).
56. NW $\frac{1}{4}$ sec. 30, T3S, R36E, near Rogers, USGS Mesozoic Locality 16450, Roosevelt County (Young, 1966).
57. Sec. 34, T8N, R32E, Quay County (USGS collection locality), Pajarito Shale.



Pecos River terrace deposits on western edge of Sunshine Mesa (photo: S. G. Lucas).