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TRIASSIC MICROVERTEBRATE LOCALITY, CHINLE FORMATION, EAST-CENTRAL NEW MEXICO

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INTRODUCTION

Fossil vertebrates from the Upper Triassic strata of east-central New Mexico have been known for nearly a century. One of the longest known Triassic vertebrate collecting areas in east-central New Mexico is Bull Canyon (Fig. 1) where more than 85 m of fossiliferous strata of the upper shale member of the Chinle Formation are exposed (Lucas et al., 1984). First mentioned as a Triassic vertebrate collecting area by Case (1914), Bull Canyon has produced the holotype skull of the phytosaur *Machaeroprosopus* (=*Rutiodon*) *andersoni* Mehl, 1922, and the remains of fishes, amphibians (*"Buettneria"*) and other phytosaurs (Gregory, 1972). Since 1983, field parties from the University of New Mexico (UNM) have amassed an extensive collection of vertebrate, invertebrate and plant fossils from the upper shale member of the Chinle in Bull Canyon. This paper describes in a preliminary way the vertebrate fossils from one UNM microvertebrate locality in Bull Canyon.

PROVENANCE

The microvertebrate locality, UNM locality V-601,is in the upper shale member of the Chinle Formation in the SW1/4 SW1/4 SE1/4 sec. 28, T9N, R26E (Fig. 1). It is one of many vertebrate localities in the upper shale member in the southwestern fork of Bull Canyon (Fig. 1). These localities comprise two vertebrate-producing intervals: a lower interval where phytosaur remains are particularly abundant and nonmarine invertebrates (Kues, 1985) and pith casts of *Neocalamites* also are present, and an upper interval that includes locality V-601 (Lucas et al., 1985).

The microvertebrate locality is in a 0.3-m-thick layer of sandy/gravelly, pale reddish-brown (10 R 5/4: Goddard et al., 1979) mudstone (Figs. 1, 2). This layer is 22.9 m below the base of the Redonda Member of the Chinle Formation (Figs. 1, 2). The bone-bearing layer is fossiliferous for more than 100 m along strike. Collection of this layer was by surface picking and wet screenwashing (30-per-inch grid) of about two tons of sediment. Specimens were further concentrated using a water column before picking.

VERTEBRATE FAUNA

Fishes

Remains of fishes from locality V-601 mostly consist of isolated scales and fragments of ribs and fin-rays. These specimens are often encased in coprolites (see later discussion and Figure 7, S–U). Almost all of these scales are small, rhomboidal in outline and ganoid; in other words, one of their flat surfaces is coated with a smooth, dark, shiney veneer of ganoine. These scales resemble those of redfieldiid palaeonisciforms (Schaeffer and McDonald, 1978). A single specimen, UNM MV-547, has raised ridges and resembles the dermal bones of the opercular region of the chondrostean *Ptycholepis* (Schaeffer et al., 1975).

Amphibia

Amphibian remains are relatively rare in the upper shale member of the Chinle Formation in Bull Canyon (Lucas et al., 1985; Lucas and Kietzke, in press). One of the few specimens from locality V-601 is a fragment of an interclavicle, UNM MV-520 (Fig. 3A). The size and pronounced ridge-and-pit sculpturing of this bone are consistent with assignment to the large metoposaurid *Eupelor* (Colbert and Imbrie, 1956, pl. 27). However, precise identification of UNM MV-520, and of UNM MV-511, additional labyrinthodont bone fragments from locality V-601, is impossible. UNM MV-531 (Fig. 4L) apparently is the conical tip of a labyrinthodont tooth (see Huene, 1921, fig. 16).

Parasuchia

Phytosaur teeth, isolated postcrania and bone fragments are a major component of the vertebrate fossils from UNM locality V-601, as they are at all localities in the upper shale member of the Chinle in Bull Canyon (Lucas et al., 1985; Lucas and Kietzke, in press). Typical, isolated phytosaur teeth from locality V-601 (Fig. 4A–B, E–K, P–S) are comparable to those illustrated by Huene (1921, figs. 5, 7, 12, 16). Isolated postcrania of phytosaurs, not illustrated here, include a variety of dorsal centra and isolated limb fragments (UNM MV-502, 504 and 523).

Two complete skulls of *Rutiodon*, the holotype of *R. andersoni* (Mehl, 1922), and UNM MV-650, a skull we identify as *R.* cf. *R. adamanensis* (Lucas et al., 1985), have been collected from the upper shale member of the Chinle in Bull Canyon. The phytosaur teeth and postcrania from locality V-601 are within the size range of those of *Rutiodon* (Camp, 1930). Therefore, we provisionally refer the specimens from UNM locality V-601 to *Rutiodon* sp., although the possibility that some may represent *Nicrosaurus*, also known from the upper shale member of the Chinle in east-central New Mexico (Gregory, 1972), cannot be discounted.

UNM MV-513 (Fig. 3B–C) is the left anterior tip of the rostrum of a very small phytosaur. Its ventral aspect (Fig. 3B) reveals four alveoli, two larger anterior alveoli followed by two smaller ones. The medial aspect of UNM MV-513 (Fig. 3C) reveals a flat, corrugated sutural surface for the right premaxillary. As far as we know, this is the ontogenetically youngest phytosaur mentioned in the literature; it is much smaller than any juvenile phytosaur described by Camp (1930).

Cf. *Coelophysis*

Two laterally compressed teeth with finely serrated edges (Fig. 4C–D, Q–R) from locality V-601 are very similar to those of theropod saurischians. They closely resemble dinosaur teeth illustrated by Case (1932, figs. 4–5), and we provisionally refer them to *Coelophysis* sp.

Incomplete metapodials and phalanges from locality V-601 (Fig. 3D–O) also appear to belong to *Coelophysis* (see Huene, 1915, figs. 34–37; Steel, 1970, fig. 7). An isolated dorsal vertebral centrum, UNM MV-535, closely resembles dorsal centra of *Coelophysis* (Huene, 1915; Case, 1922, 1932) and is tentatively referred to that genus.

Fabrosauridae

UNM MV-552 (Fig. 5) is a small, laterally compressed, leaf-shaped tooth with denticulated occlusal edges. This tooth is remarkably similar to teeth of fabrosaurid ornithischians from the Upper Triassic of Texas (Chatterjee, 1984, fig. 1) and the Lower Jurassic(?) of Arizona (Colbert, 1981, figs. 8, 10). We are reluctant to assign a genus and species name to UNM MV-552, but cannot distinguish it from *Technosaurus* Chatterjee, 1984, from the upper part of the Dockum Group ("upper shale unit" of Drake, 1892) in Garza County, Texas.

Cynodontia

UNM MV-518 (Fig. 6) is a lower-jaw fragment bearing a single tooth, and a detached tooth from this jaw fragment (Fig. 6B–C), that we tentatively refer to the Cynodontia. The dentary of this specimen is relatively deep, long and robust. The two teeth are tricuspate, laterally compressed and striated. The central cusps of these teeth are much larger than the other two cusps and their apices slope posteriorly.

Comparison of UNM MV-518 with the teeth of the Triassic pterosaur *Eudimorphodon* (Wild, 1978) suggests that UNM MV-518 is not a pterosaur for the following reasons:

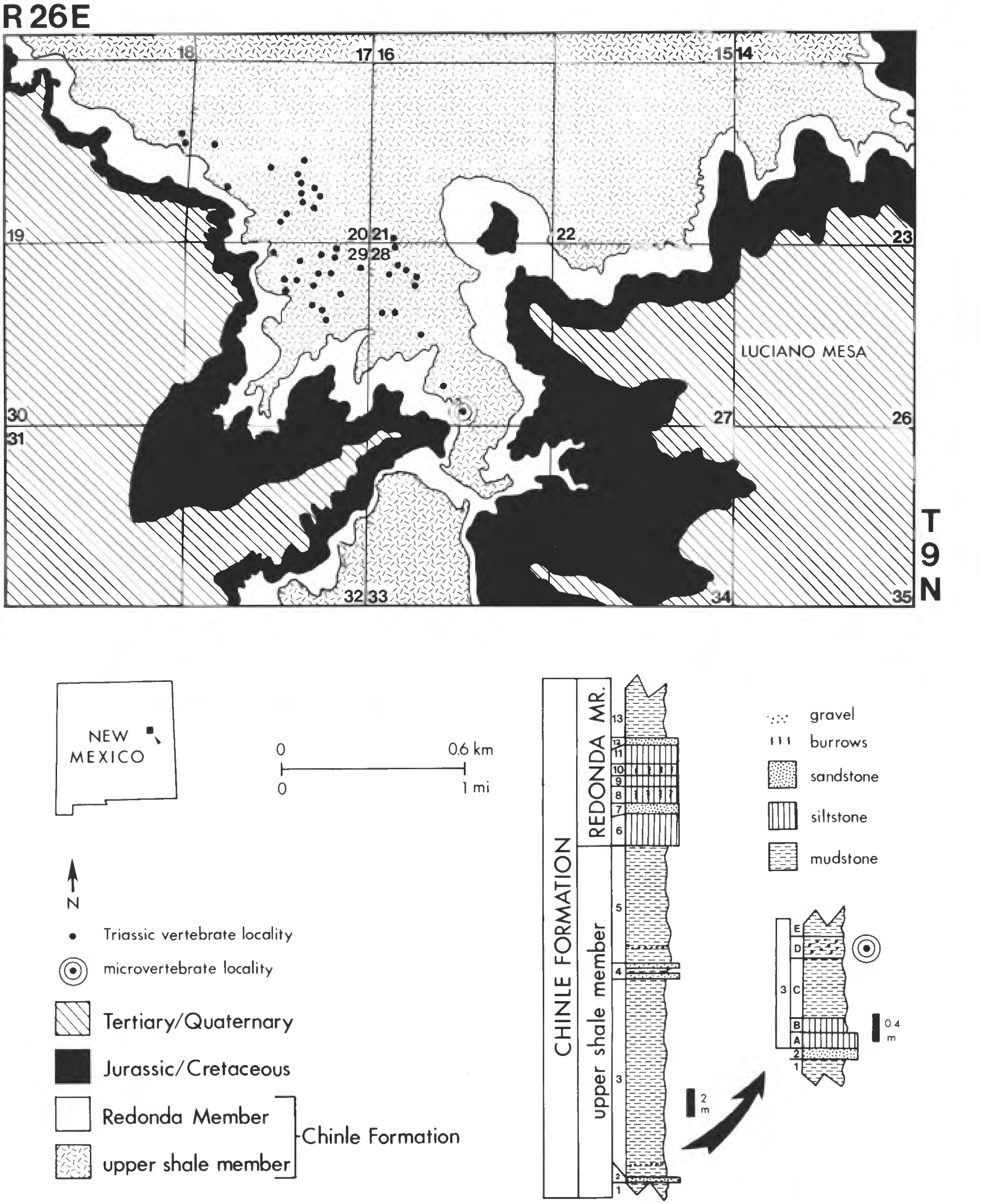

FIGURE 1. Geologic map of the southern end of Bull Canyon and measured stratigraphic section at UNM locality V-601 (microvertebrate locality). See the Appendix to this paper for description of the measured stratigraphic section.

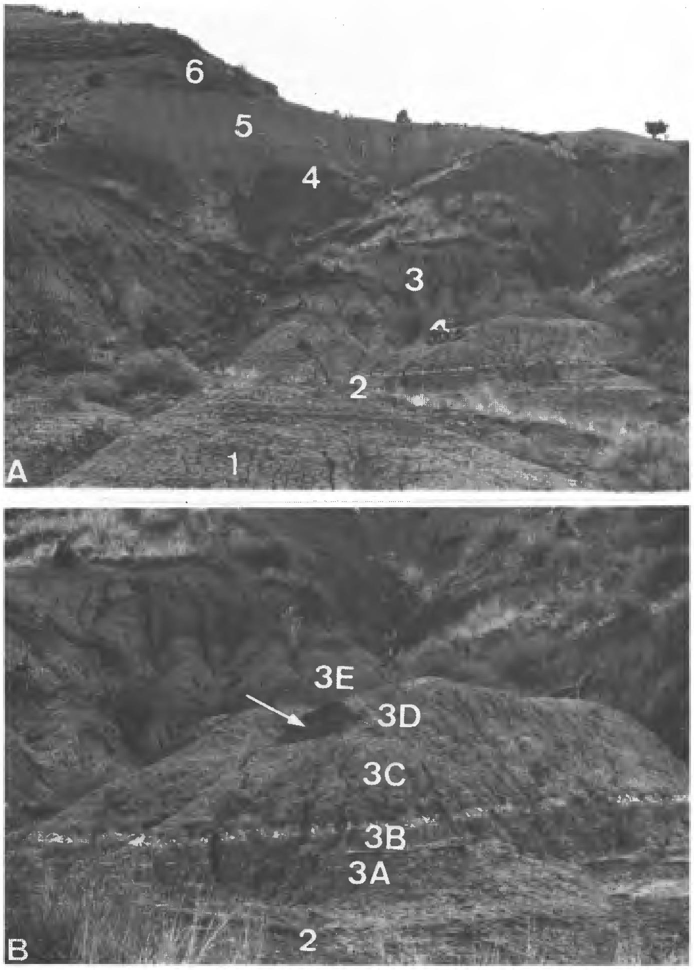

FIGURE 2. Two views of UNM locality V-601. The arrow in B indicates where screenwashing samples were collected. Numbers refer to units of the measured stratigraphic section of Figure 1.

1. The central cusps of the teeth of *Eudimorphodon* are much taller relative to the other two cusps than is the case in UNM MV-518 (Wild, 1978, fig. 8).

2. The cross section of the teeth of *Eudimorphodon* is rectangular at the base of the crown and widely and irregularly biconvex in a plane through the apices of the anterior and posterior cusps (R. Wild, written comm. 1985). In contrast, the cross section of the teeth of UNM MV-518 is narrowly and regularly biconvex.

3. Even though cusp proportions and cross sections of the teeth of UNM MV-518 are somewhat similar to those of juvenile *Eudimorphodon,* the juvenile teeth of *Eudimorphodon* lack striae and have smooth enamel (R. Wild, written comm. 1985).

The features that distinguish UNM MV-518 from *Eudimorphodon* are characteristic of small cynodonts (see, for example, Peyer, 1956, pl. 2, fig. 58, pl. 12, fig. 47; Lehman, 1961, fig. 17). For this reason, we tentatively assign UNM MV-518 to the Cynodontia, although further study is necessary (and planned) to determine its precise affinities.

Coprolites

Coprolites are a significant component of the specimens collected at UNM locality V-601. Three types of coprolites can be recognized on the basis of size, shape, surface texture and presence/absence of visible bone and/or fish scales.

Type A coprolites

More than 90% of the coprolites from locality V-601 are relatively small (up to 2.1 cm long and 1.1 cm in diameter), rod-like to oval

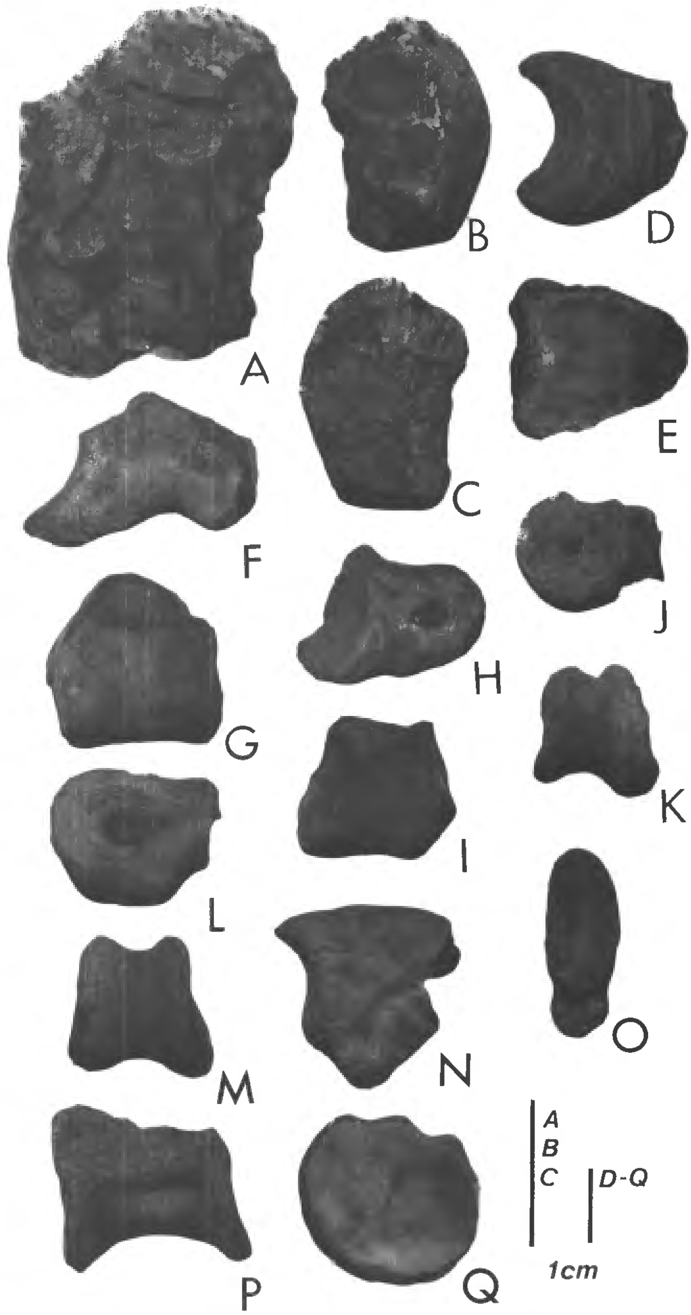

FIGURE 3. Labyrinthodont, phytosaur and cf. *Coelophysis* sp. A, UNM MV-520, ventral aspect of labyrinthodont interclavicle fragment. B–C, UNM MV-513, fragment of rostrum of a juvenile phytosaur, ventral (B) and medial (C) aspects. D–E, UNM MV-503a, cf. *Coelophysis* sp., right claw fragment, medial (D) and proximal (E) views. F–G, UNM MV-503b, cf. *Coelophysis* sp., right phalanx, lateral (F) and proximal (G) views. H–I, UNM MV-503c, cf. *Coelophysis* sp., right phalanx, lateral (H) and proximal (I) views. J–K, UNM MV-503d, cf. *Coelophysis* sp., right metapodial fragment, medial (J) and distal (K) views. L–M, UNM MV-503e, cf. *Coelophysis* sp., right metapodial fragment, medial (L) and distal (M) views. N–O, UNM MV-503f, cf. *Coelophysis* sp., right claw fragment, medial (N) and proximal (O) views. P–Q, UNM MV-535, cf. *Coelophysis* sp., dorsal vertebral centrum, lateral (P) and anterior (Q) aspects.

(terminology of Häntzschel et al., 1968, fig. 1), circular in cross section and have a nearly smooth surface texture (Fig. 7A–L). Some of these type A coprolites have spiral grooves at their tips (Fig. 7A–B, K–L), the spiral terminating at a point. Fish scales are visible on the surfaces or in cross sections of some of these coprolites.

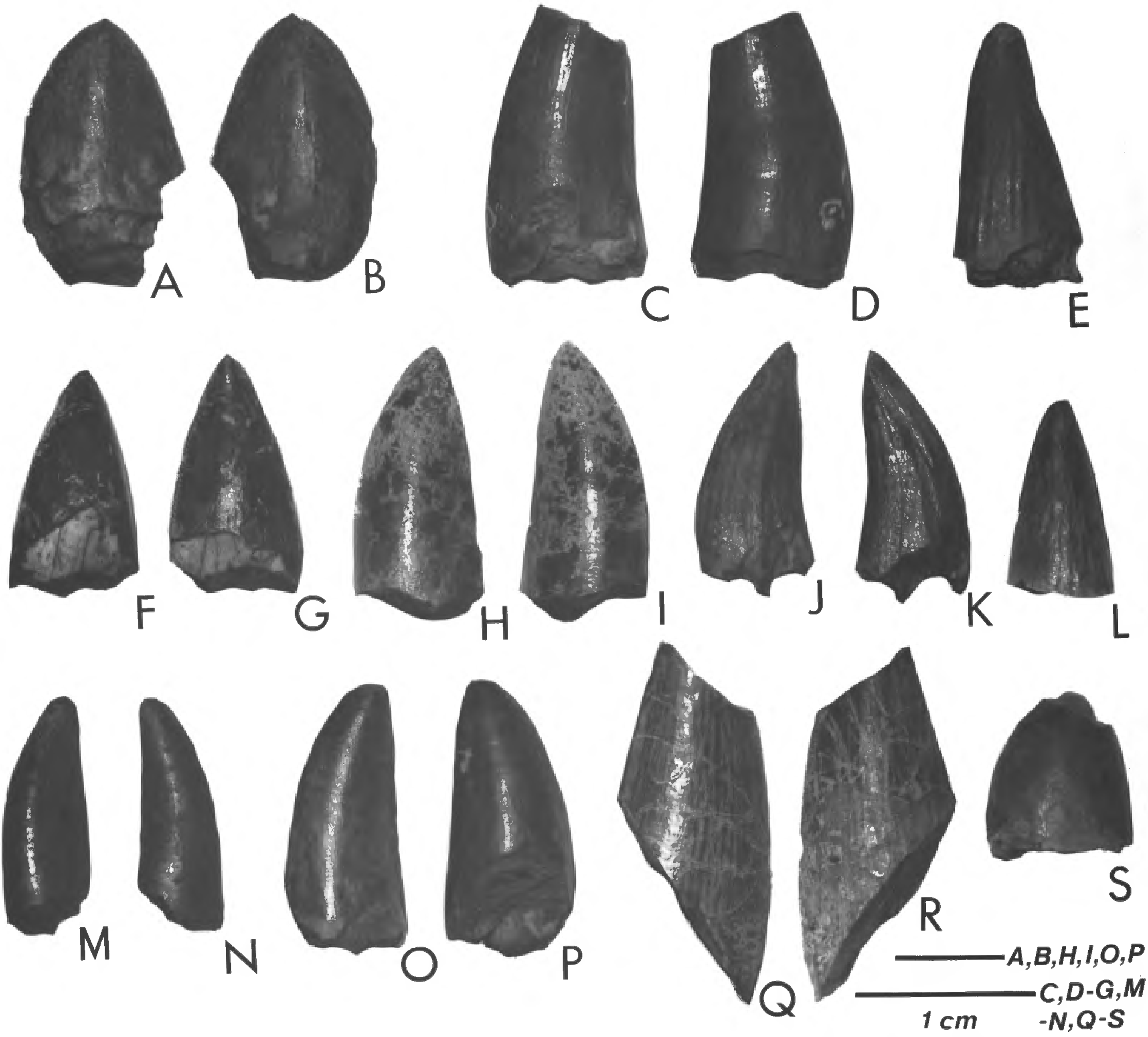

FIGURE 4. Teeth of phytosaurs, cf. *Coelophysis* and a labyrinthodont. A–B, UNM MV-528, posterior tooth of a phytosaur. C–D, UNM MV-516, tooth of cf. *Coelophysis* sp. E, UNM MV-522, anterior tooth of a phytosaur. F–G, UNM MV-524, tooth of a phytosaur. H–I, UNM MV-526, posterior tooth of a phytosaur. J–K, UNM MV-530, anterior tooth of a phytosaur. L, UNM MV-531, tip of labyrinthodont tooth. M–N, UNM MV-529, anterior tooth of a phytosaur(?). O–P, UNM MV-527, posterior tooth of a phytosaur. Q–R, UNM MV-525, tooth of cf. *Coelophysis* sp. S, UNM MV-533, posterior tooth of a phytosaur.

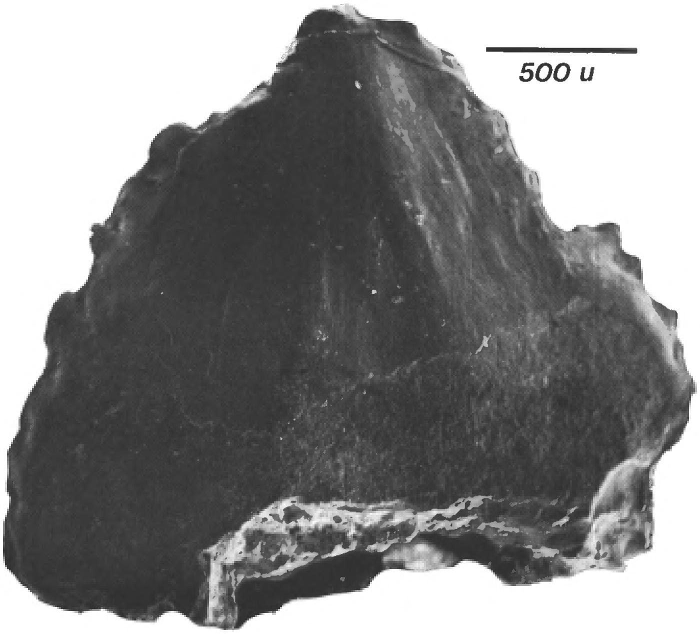

FIGURE 5. UNM MV-552, lateral view of a tooth of a fabrosaurid ornithischian.

These coprolites resemble Case's (1922, p. 84) "second type of coprolite." However, type A coprolites from locality V-601 do not have as pronounced spiral grooves and are not as large as some of those described by Case (1922). In addition, Case (1922) did not mention the presence of fish scales in his "second type" of coprolite. Type A coprolites described here generally resemble all except one of the coprolites illustrated by Ash (1978, fig. 2; the exception is Ash's fig. 2g). However, the coprolites illustrated by Ash (1978) lack fish scales.

Type B coprolites

Type B coprolites (Fig. 7M–R) overlap in size with type A coprolites, but have a different shape and surface texture and lack fish scales or bone. These coprolites are curved (some approach a crescent shape), subcircular to oval in cross section and have deep, regularly spaced furrows that run along their long axes.

These coprolites are essentially identical to Case's (1922, p. 84) "third type of coprolite," although no type B coprolite from UNM locality V-601 is as large as some of those reported by Case (1922). Type B coprolites resemble one coprolite illustrated by Ash (1978, fig. 2g).

Type C coprolites

The collection from locality V-601 includes two relatively large coprolites (Fig. 7S–U). These type C coprolites are irregularly shaped, have irregularly shaped cross sections and rough textures and contain numerous fish scales and bone fragments. The bone in the two type C coprolites apparently is fish and all of the scales are small, rhomboidal and ganoid.

Type C coprolites have no exact counterparts among the coprolites described by Case (1922) and Ash (1978). Although Case (1922, p. 83) mentioned large coprolites, he described them as "generally regular, with smooth surfaces" and lacking bone or scales.

Discussion

Although there is a large literature on coprolites (e.g., Häntzschel et al., 1968), attempts to identify their sources, particularly in the case of Triassic coprolites from the American Southwest, have generally been little more than speculation (Case, 1922; Ash, 1978). Case (1922) attributed the coprolites we term type B to amphibians. The virtual absence of amphibian body-fossils at UNM locality V-601, and, indeed, in the upper shale member of the Chinle throughout Bull Canyon, casts doubt on this attribution. The absence of bone and fish scales, size and surface texture (which suggests a spiral or annular convolution of the intestine) are consistent with attributing type B coprolites to herbivorous and/or microphagous fishes (cf. Ash, 1978). However, this conclusion cannot otherwise be supported. Type A and C coprolites obviously were produced by fish-eating vertebrates, possibly fishes or phytosaurs.

BIOSTRATIGRAPHIC SIGNIFICANCE

The upper shale member of the Chinle Formation in east-central New Mexico has been correlated with the Petrified Forest and Owl Rock Members of the Chinle Formation in northeastern Arizona and northwestern New Mexico (Colbert and Gregory, 1957, table 3). The occurrence of cf. *Eupelor* sp., *Rutiodon* sp. and cf. *Coelophysis* sp. at UNM locality V-601 (Table 1), in the uppermost upper shale member of the Chinle, supports correlation of the upper shale member of the Chinle in east-central New Mexico with the Petrified Forest Member in northeastern Arizona and northwestern New Mexico. However, we believe there is a good reason to correlate the Owl Rock Member of the Chinle in northeastern Arizona and northwestern New Mexico with the Redonda Member of the Chinle of east-central New Mexico (Lucas et al., 1985).

Colbert and Gregory (1957, table 3) considered the upper shale member of the Chinle Formation in east-central New Mexico to be equivalent to, and in its upper part slightly younger than, the Trujillo Formation of the Dockum Group in western Texas. However, physical stratigraphy (Finch et al., 1976; Finch and Wright, 1983) indicates that the Trujillo is equivalent to the Cuervo Member of the Chinle, the member that underlies the upper shale member throughout east-central New Mexico (Kelley, 1972a, b; Lucas et al., 1985). This suggests that the upper shale member of the Chinle in east-central New Mexico is younger than the Trujillo, an equivalent of Drake's (1892) "upper shale unit" of the Dockum in Borden and Garza Counties, Texas (Lucas et al., 1985). The vertebrates from UNM locality V-601 do not contradict this correlation, although this locality lacks the taxa restricted to the upper shale unit in Texas that would strongly support such a correlation (Chatterjee, in press).

The presence of a cynodont at UNM locality V-601 has significant biostratigraphic and paleogeographic implications. The classic fossil record of cynodonts is from the Triassic of South Africa (Kemp, 1982). Their presence in the Upper Triassic of North America supports the concept of a land connection between Gondwanaland and Laurasia during the Triassic (Chatterjee, in press). A more precise identification of UNM MV-518 may also aid in intercontinental correlation of the Chinle Formation. However, such a correlation must await further study of this specimen.

ACKNOWLEDGMENTS

We are grateful to Reilly Ltd., through Pauline Houlihan, for permission to collect vertebrate fossils in Bull Canyon. Numerous UNM students, especially during the 1983 and 1984 Summer Vertebrate Paleontology Field Schools, assisted in collecting UNM locality V-601,

TABLE 1. Vertebrate taxa from UNM locality V-601, upper shale member of Chinle Formation, Bull Canyon, New Mexico.

Class OSTEICHTHYES	*Rutiodon* sp.
Redfieldiidae	Order SAURISCHIA
cf. *Ptycholepis* sp.	cf. *Coelophysis* sp.
Class AMPHIBIA	Order ORNITHISCHIA
cf. *Eupelor* sp.	Fabrosauridae
Class REPTILIA	Order THERAPSIDA
Order THECODONTIA	Cynodontia

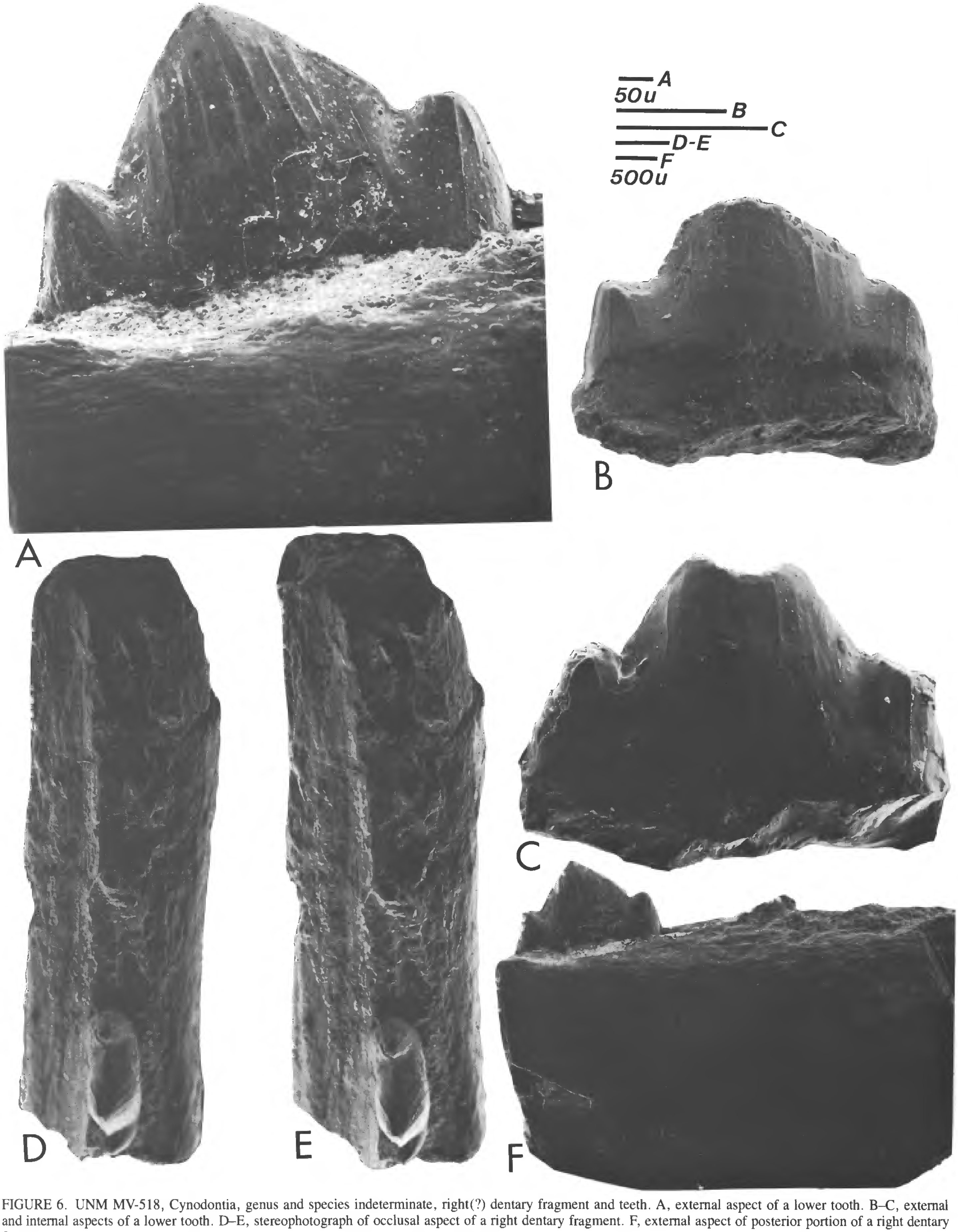

FIGURE 6. UNM MV-518, Cynodontia, genus and species indeterminate, right(?) dentary fragment and teeth. A, external aspect of a lower tooth. B–C, external and internal aspects of a lower tooth. D–E, stereophotograph of occlusal aspect of a right dentary fragment. F, external aspect of posterior portion of a right dentary fragment.

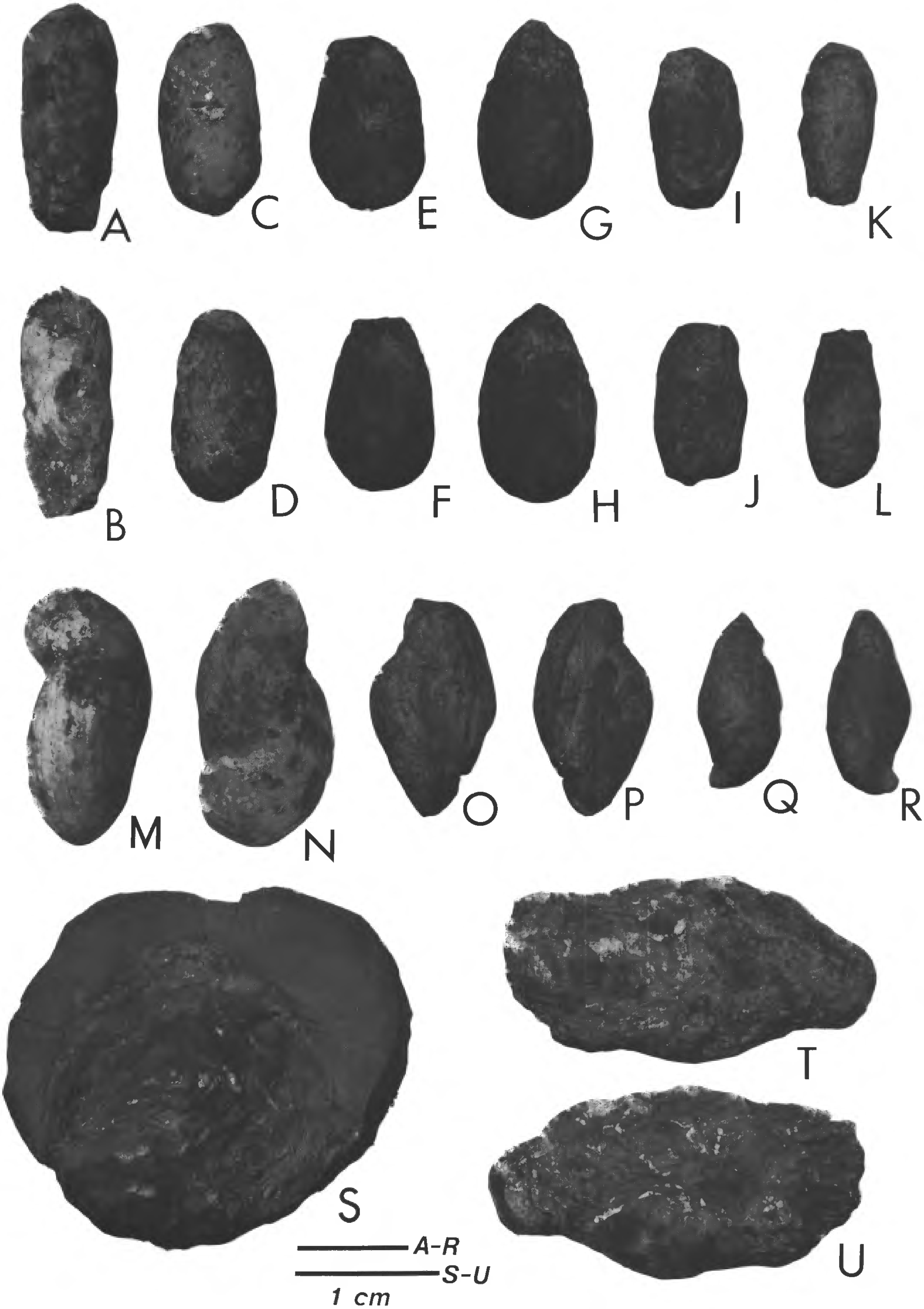

FIGURE 7. Coprolites from UNM locality V-601. A–B, UNM MV-536a, two views. C–D, UNM MV-536b, two views. E–F, UNM MV-536c, two views. G–H, UNM MV-536d, two views. I–J, UNM MV-536e, two views. K–L, UNM MV-536f, two views. M–N, UNM MV-537a, two views. O–P, UNM MV-537b, two views. Q–R, UNM MV-537c, two views. S, UNM MV-514a, view showing concretionary cover in cross section. T–V, UNM MV-514b, two views showing numerous fish scales.

and we are appreciative of their help. S. Chatterjee, N. Mateer and R. Wild provided insight into the identification of UNM MV-518, and A. Hunt provided assistance in stratigraphic fieldwork. P. Reser aided in specimen preparation. A. Hunt, B. Kues and N. Mateer reviewed an earlier draft of this paper.

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APPENDIX

The measured stratigraphic section shown in Figure 1 is described below. Colors are those of Goddard et al. (1979). The microvertebrate locality is in layer 3D.

Unit	Lithology	Thickness (m)
Chinle Formation:		
Redonda Member:		
13	Mudstone, moderate reddish-orange (10 R 6/6) to light-brown (5 YR 5/6).	6.20+
12	Sandstone, fine-grained, laminated, light-brown (5 YR 5/6).	0.50
11	Siltstone, not bioturbated, pale reddish-brown (10 R 5/4).	1.25
10	Siltstone, bioturbated, pale reddish-brown (10 R 5/4).	0.50
9	Siltstone, not bioturbated, moderate reddish-brown (10 R 4/6).	0.60
8	Siltstone, bioturbated, moderate reddish-brown (10 R 4/6).	1.50
7	Sandstone, fine-grained, massive, light-brown (5 YR 5/6).	0.60
6	Siltstone, not bioturbated, light-green (5 G 7/4) and grayish blue-green (5 BG 5/2), mottled.	2.75
Upper shale member:		
5	Mudstone, pale reddish-brown (10 R 5/4), with a gravelly layer near its base.	8.90
4	Interbedded fine sandstone and mudstone, grayish-red (10 R 4/2) to dark reddish-brown (10 R 3/4).	1.00
3E	Mudstone, dark reddish-brown (10 R 3/4).	13.00
3D	Mudstone with sand and gravel, pale reddish-brown (10 R 5/4).	0.30
3C	Mudstone, pale reddish-brown (10 R 5/4).	0.90
3B	Siltstone, pale green (5 G 7/2) and pale reddish-brown (10 R 5/4).	0.20
3A	Siltstone, pale reddish-brown (10 R 5/4).	0.25
2	Sandstone, fine- to medium-grained, pale reddish-brown (10 R 5/4).	0.30
1	Mudstone, pale reddish-brown (10 R 5/4).	1.00+