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THE CERATOPSIAN DINOSAUR *TOROSAURUS* FROM THE UPPER CRETACEOUS McRAE FORMATION, SIERRA COUNTY, NEW MEXICO

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Abstract—A partial skull and some associated postcrania of a large ceratopsid dinosaur from the Hall Lake Member of the McRae Formation are identified as *Torosaurus latus* Marsh. This further confirms assignment of a Lancian (late Maastrichtian) age to the Hall Lake Member.

INTRODUCTION

Lee (1905) first reported dinosaur fossils from the McRae Formation in Sierra County—a partial skeleton of a ceratopsian dinosaur identified by J. W. Gidley as *Triceratops*. Lozinsky et al. (1984), Wolberg et al. (1986) and Gillette et al. (1986) subsequently described dinosaur fossils from several localities in the Hall Lake Member of the McRae Formation (Fig. 1). Based on these fossils, they identified *Tyrannosaurus rex*, Theropoda, *Alamosaurus* sp., Hadrosauridae, Ceratopsidae and Ankylosauridae. As Lozinsky et al. (1984) and Wolberg et al. (1986) noted, the ceratopsid material collected by Lee is not diagnostic of a genus. Lee's specimen, and subsequently collected ceratopsid specimens, only indicate the presence of a large, fenestrate-frilled ceratopsid about the size of *Torosaurus* or *Pentaceratops*. Here, we document diagnostic cranial material of *Torosaurus* and some associated postcrania from the Hall Lake Member of the McRae Formation.

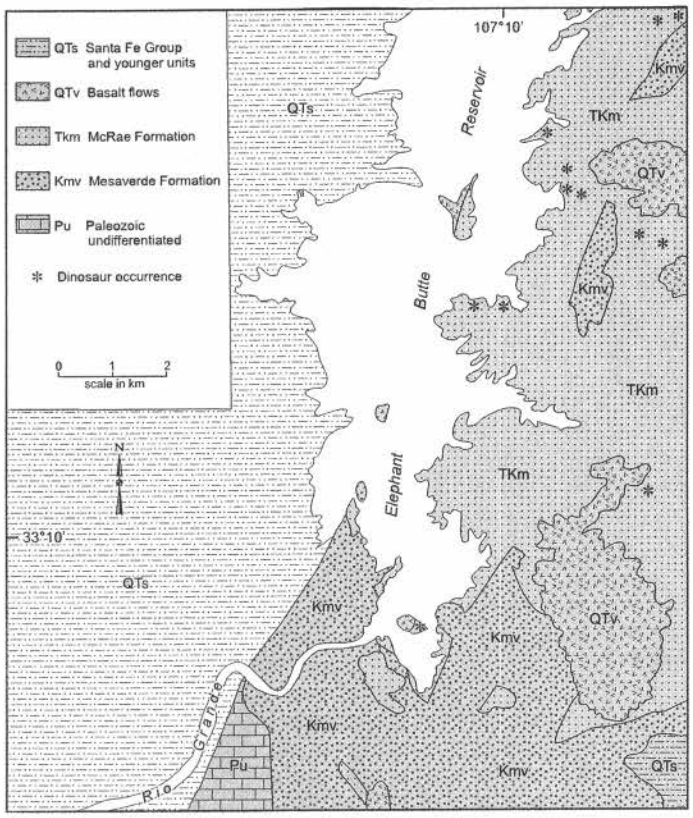

FIGURE 1. Geologic map of the Elephant Butte Reservoir area showing dinosaur localities in the Hall Lake Member of the McRae Formation (after Wolberg et al., 1986).

GEOLOGICAL CONTEXT

One of us (GHM) discovered the ceratopsid locality while undertaking geologic mapping of the Engle quadrangle east of Elephant Butte Reservoir (Fig. 1). The ceratopsid site, NMMNH (New Mexico Museum of Natural History) locality 3650, is in grayish red and olive gray mudstone in the Hall Lake Member of the McRae Formation. Here, the strata dip 8° NE, and vertebrate bones and teeth are exposed through a section about 24 m thick. (Fig. 2). All the ceratopsid material described here is from the lowest bone-producing level in the section and was found disarticulated over a 10 m^2 area. The next highest bone level produces smaller ceratopsid

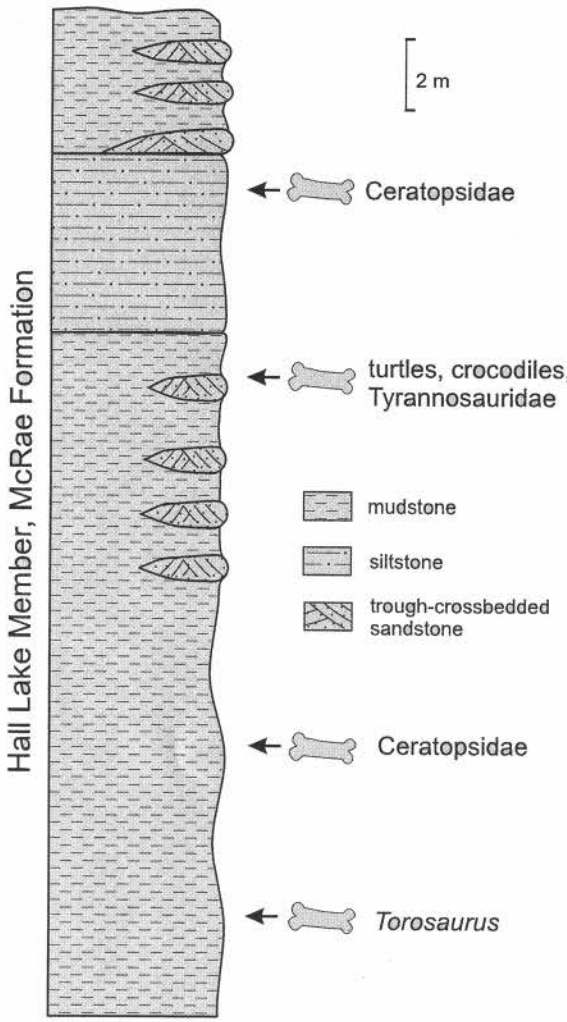

FIGURE 2. Measured stratigraphic section at NMMNH locality 3650, showing stratigraphic distribution of vertebrate fossils.

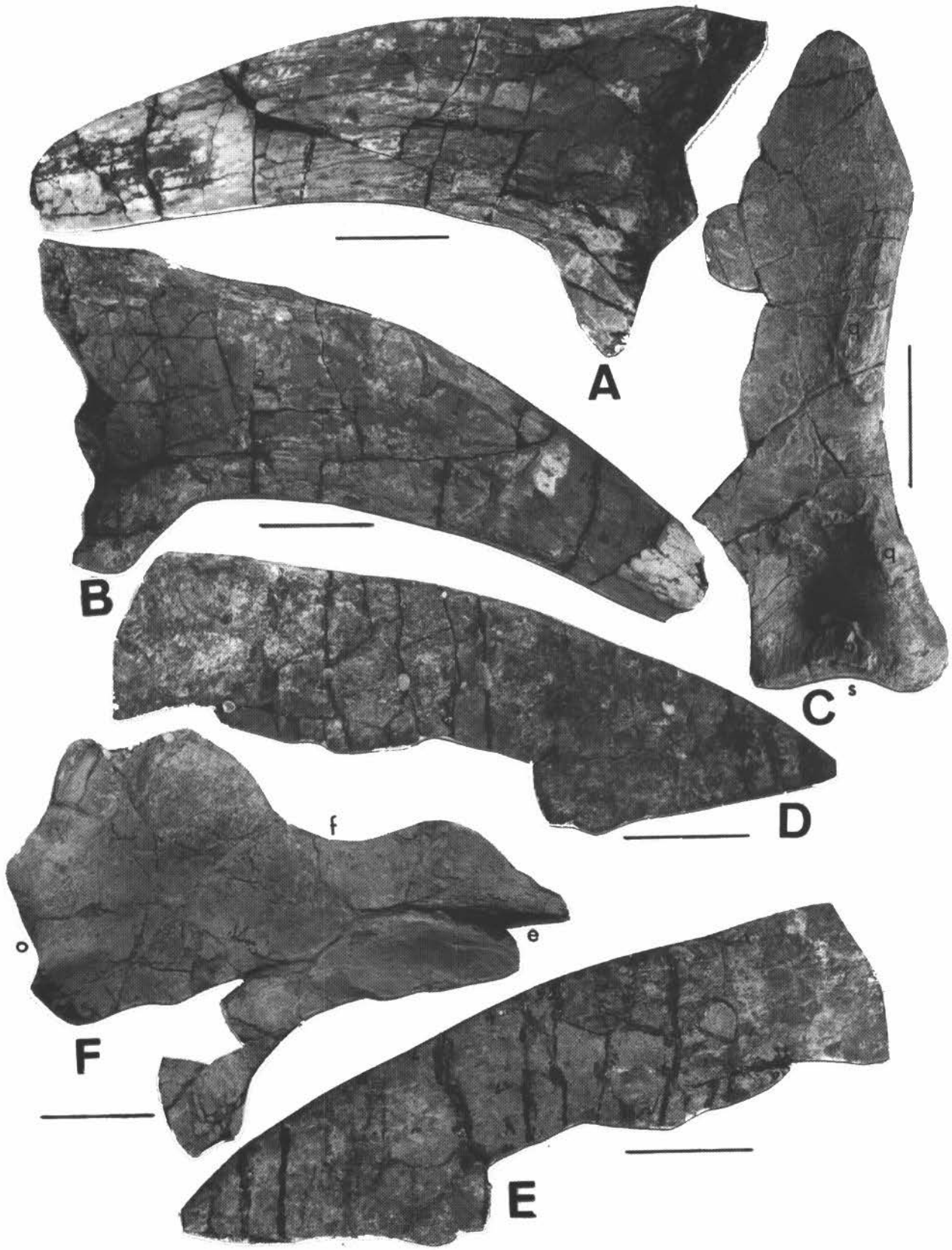

FIGURE 3. Selected cranial elements of *Torosaurus latus* from the McRae Formation. **A–B**, Right supraorbital horn core, medial **(A)** and lateral **(B)** views. **C**, Left quadrate, external view. **D–E**, Partial right squamosal, dorsal **(D)** and ventral **(E)** views. **F**, Right jugal, medial view. Abbreviations are: e = epijugal, f = lateral temporal fenestra, o = orbit, q = quadratojugal surface, s = articular surface for lower jaw. Bar scales = 10 cm.

phalanges, vertebrae and limb bone fragments. Higher in the section are levels that produce turtle shell fragments, crocodilian teeth, tyrannosaurid teeth and ceratopsid postcrania (Fig. 2).

TOROSAURUS

Cranial material

The ceratopsid fossils illustrated here are in the New Mexico State University Museum (Fig. 3A–B, D–E) or are on loan from the landowner to the New Mexico Museum of Natural History. The cranial material clearly represents a single individual because of its close proximity in the field, size similarity and similar preservation. However, the postcrania were more loosely associated with the cranial material, and the presence of a single individual among the postcrania is probable, but not certain.

Horn core

A large, thick, curved but incomplete supraorbital horn core (Fig. 3A–B) has a length of at least 60 cm. Neither the orbital margin nor the basal sinus of the horn core are preserved. It tapers distally and is compressed laterally, so the cross section is elliptical. These features and strong anterior inclination are points of close resemblance to the horn core of *Torosaurus* (Hatcher et al., 1907, fig. 119; Lull, 1933, pl. 15; Gilmore, 1946, fig. 12).

Jugal

The right jugal (Fig. 3F) preserves a concave, 100-mm-long, inferior margin to the right orbit. The process for the epijugal is a relatively long blade, but the epijugal is not preserved, and the posterior edge of the jugal preserves the concave edge of the lateral temporal fenestra. This bone closely resembles previously illustrated jugals of *Torosaurus* (Lull, 1933, pl. 16; Gilmore, 1946, fig. 12).

Squamosal

An incomplete distal portion of a right squamosal (Fig. 3D–E) is a relatively thin, blade-like bone that tapers to a posterior pointed tip. The lateral edge of the squamosal is a nearly smooth edge that lacks articular surfaces for epoccipitals; indeed, no epoccipitals were found with the cranial material. This squamosal well matches illustrated squamosals of *Torosaurus* (Hatcher et al., 1907, figs. 12, 14; Gilmore, 1946, fig. 12).

Quadrate

The left quadrate (Fig. 3C) has a saddle-shaped articular surface for the lower jaw that is 130 mm wide; total preserved height is 440 mm. The flange-like surface that is overlapped by the pterygoid has been broken away, but the long, rugose surfaces for the quadratojugal are prominent. The quadrate of *Torosaurus* is not well illustrated, but this bone well matches written descriptions of the bone by Hatcher et al. (1907) and Gilmore (1946).

Postcranial material

Dorsal vertebra

Three dorsal vertebrae were collected; the one illustrated (Fig. 4A) is characteristic. The centrum is tall and pear-shaped in articular view; centrum height = 180 mm, maximum width = 162 mm. Above a small, nearly circular neural canal a tall neural arch has well-preserved zygopophyses and is capped by a long neural spine. This is a typical posterior dorsal vertebra of a ceratopsid (cf. Hatcher et al., 1907, fig. 52).

Rib

One dorsal rib was collected (Fig. 4B) and has an arc length of at least 1.1 m (the distal end is incomplete). This rib has two well separated proximal articular ends (the tuberculum and capitulum). Because of its size and strongly arched outline, it is a typical ceratopsid anterior dorsal rib (Hatcher et al., 1907).

Scapula

A left scapula (Fig. 4E) has a total length of at least 890 mm and a 170-mm-long glenoid fossa. The blade is long, thin and has a convex-to-straight anterior edge and a concave-to-straight posterior edge. It is a typical ceratopsid scapula (cf. Hatcher et al., 1907, fig. 64).

Coracoid

A left coracoid (Fig. 4C) has a 150-mm-long glenoid fossa, and a maximum length of 330 mm. It is perforated by a large, ovoid coracoid foramen, and there is a prominent, arched coracoid process. This is a typical ceratopsid coracoid (cf. Hatcher et al., 1907, fig. 64).

Ilium

An incomplete left ilium (Fig. 4D) has a total preserved length of 580 mm and a 190-mm-long, concave acetabular margin. The anterior iliac process is long and blade-like, whereas the acetabular margin is short and thick. This ilium is characteristically ceratopsid (cf. Hatcher et al., 1907, figs. 60–61).

Identification

The relatively large size, fenestrate frill, lack of epoccipitals, long and smooth-edged squamosals, and prominent epijugal process are features of the McRae ceratopsian that support its assignment to *Torosaurus* and preclude assignment to *Triceratops* or *Pentaceratops* (cf. Dodson and Currie, 1990). Other anatomical features of the specimen are consistent with this identification. *Torosaurus* is currently considered to be a monospecific genus (Dodson and Currie, 1990), so we identify the McRae *Torosaurus* as *T. latus* Marsh. However, as A. Farke (written commun., 1998) notes, the McRae specimen is close to *T. utahensis* (Gilmore) and could be referred to that species if *T. latus* and *T. utahensis* are considered distinct species.

DISCUSSION

The postcrania described here are the first postcrania of *Torosaurus* to be described. They suggest a large, *Triceratops*-like postcranial skeleton for *Torosaurus*.

Torosaurus is not a common Late Cretaceous ceratopsid in western North America, but its remains are widespread in deposits of late Maastrichtian (Lancian) age: Hell Creek Formation, Montana and South Dakota; Lance Formation, Wyoming; North Horn Formation, Utah; upper Kirtland Formation, San Juan Basin, New Mexico; and Javelina Formation, Big Bend National Park, Texas (e.g., Marsh, 1891; Gilmore, 1946; Colbert and Bump, 1947; Lawson, 1976; Lucas et al., 1987; Dodson and Currie, 1990). This distribution strongly supports identification of *Torosaurus* as an index fossil of the Lancian land-vertebrate "age" (= late Maastrichtian) (Lucas, 1991).

Lozinsky et al. (1984), Wolberg et al. (1986) and Gillette et al. (1986) earlier assigned the dinosaur fossils from the Hall Lake Member of the McRae Formation a Lancian age. They based this age assignment on the presence of *Tyrannosaurus*, *Alamosaurus*, and a large ceratopsid that they suggested might be *Torosaurus*. The fossils described here verify that *Torosaurus* is present in the McRae Formation and further support assigning the Hall Lake Member a Lancian age.

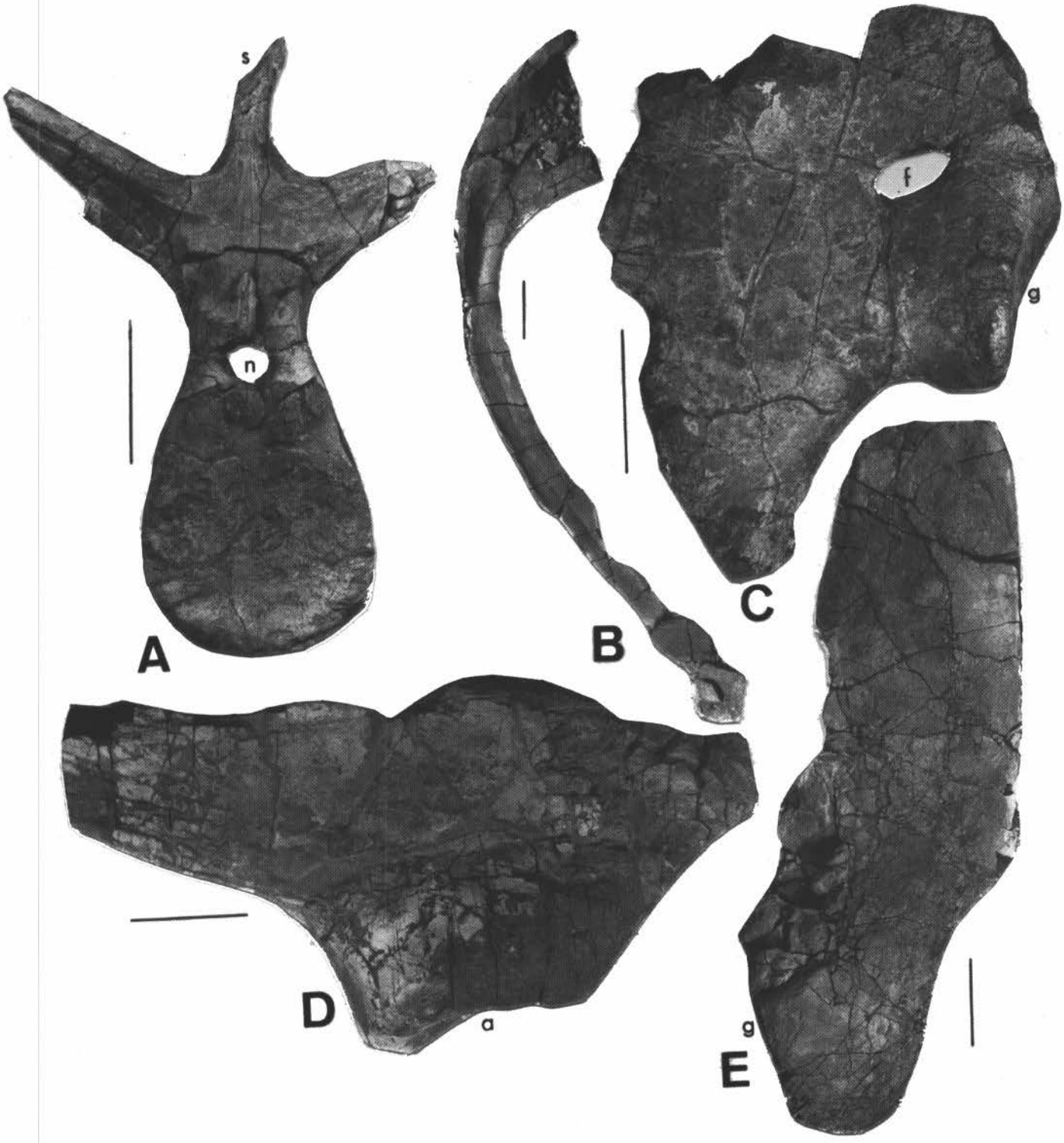

FIGURE 4. Selected postcrania of Torosaurus latus from the McRae Formation. **A**, Dorsal vertebrae, anterior view. **B**, Left dorsal rib, posterior view. **C**, Left coracoid, external view. **D**, Left ilium, ventral aspect. **E**, Left scapula, medial surface. Abbreviations are: a = acetabular surface, f = coracoid foramen, g = glenoid fossa, n = neural canal, s = neural spine. Bar scales = 10 cm.

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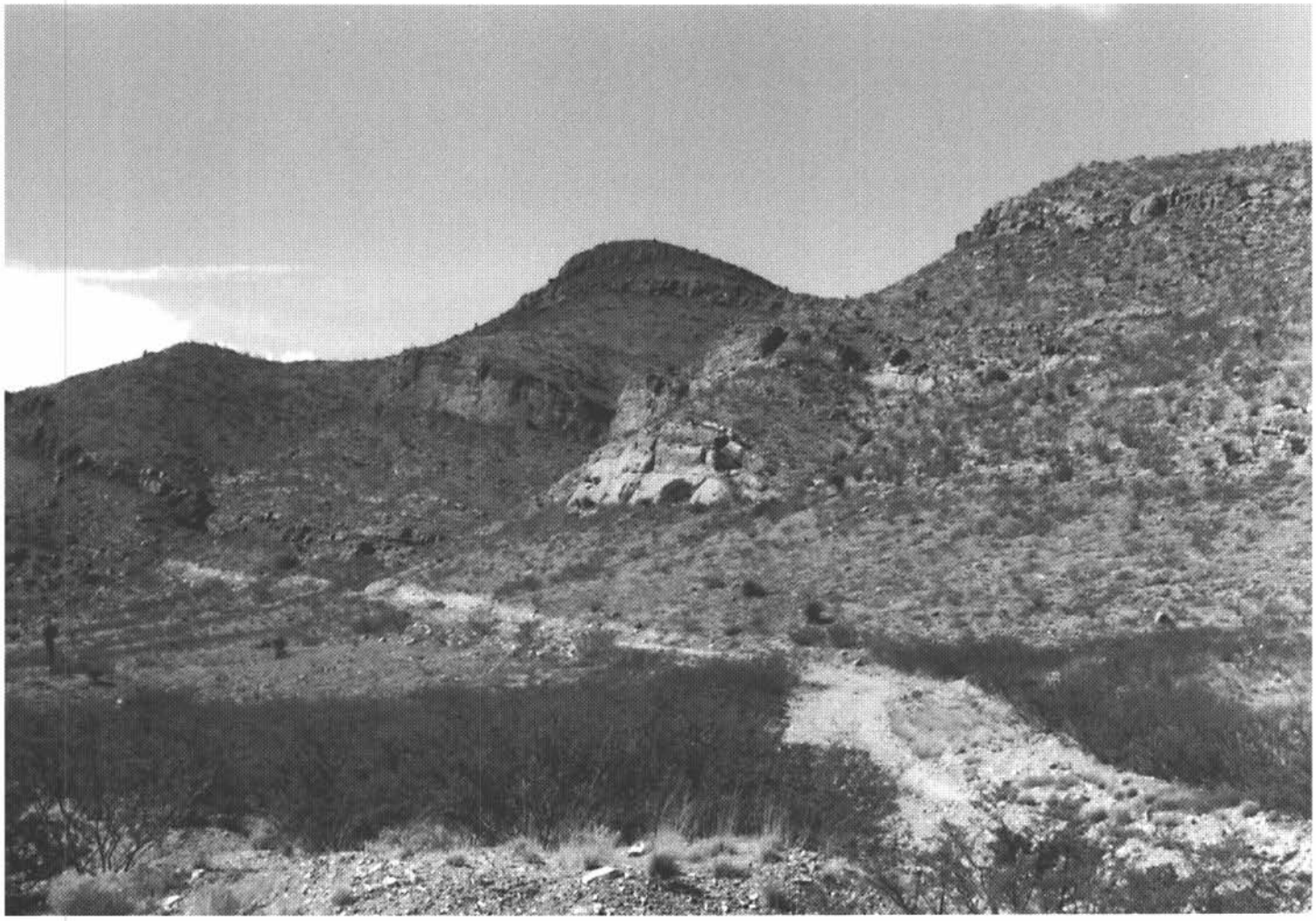

North-central part of Bishop Cap Hills, southeast of Las Cruces. Exposed are the Devonian Percha Shale (at road level), the Mississippian Lake Valley, Rancheria, and Helms Formations, and the Pennsylvanian La Tuna Formation. Just above the road in the center of the photograph is a Waulsortian mound in the Lake Valley Formation. Photograph by Greg Mack.