

## TAXONOMIC COMPOSITION OF THE ALAMO WASH LOCAL FAUNA FROM THE UPPER CRETACEOUS OJO ALAMO FORMATION (NAASHOIBITO MEMBER), SAN JUAN BASIN, NEW MEXICO

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**Abstract**— The vertebrate fauna from the Upper Cretaceous Naashoibito Member of the Ojo Alamo Formation (Sandstone), also known as the Alamo Wash local fauna (AWlf), has been the focus of intense collecting for over 20 years in order to clarify the biostratigraphic occurrences of taxa within this unit. Previously, some vertebrate taxa from the underlying De-na-zin Member of the Kirtland Formation, which lies unconformably below the Naashoibito Member, were mistakenly included in the original definition of the fauna. Therefore, the taxonomic composition of the Alamo Wash local fauna has not been properly assessed until now.

The Alamo Wash local fauna consists of a variety of vertebrate taxa, including fish, a salamander, turtles, crocodylians, dinosaurs, and mammals. The fossil vertebrates from the AWFL include a few fishes: *Myledaphus* sp., *?Squatirhina* sp., Lepisosteidae indet. and an indeterminate osteichthyan. There is an indeterminate *?Batrachosauroididae* and a few turtles, including the pleurosternid *Compsemys* sp., an indeterminate baenid, the questionable kinosternoid *Hoplochelys* sp., an indeterminate adocid, the nanhsiungchelyid *?Basilemys* sp., the trionychid *Plastomenus* sp. as well as an indeterminate trionychid. The teiid lizards *?Chamops* sp. and *Peneteius* sp. have been documented by others, but not verified by us, so we tentatively accept their presence. Crocodylians include cf. *Brachychampsa* sp. and indeterminate crocodylian material. Dinosaurs are represented by numerous theropods, including the problematic coelurosaurian *Ricardoestesia* sp., the tyrannosaurid cf. *Tyrannosaurus* sp., indeterminate ornithomimids, the caenagnathid *Ojoraptorsaurus boerei*, an indeterminate troodontid, and a new unnamed dromaeosaurid. Sauropods are represented by the titanosaur *Alamosaurus sanjuanensis*. Ankylosaurs include the nodosaurid *Glyptodontopelta mimus* and an indeterminate ankylosaurid that is close to *Euoplocephalus*. Hadrosaurs include an indeterminate lambeosaurin that is close to *Corythosaurus* and *Hypacrosaurus* as well as indeterminate hadrosaurines. The chasmosaurine *Ojoceratops fowleri* is the only diagnostic ceratopsian known, but other ceratopsid material suggests other ceratopsid taxa are present. Mammals include the neoplagiulacid *Mesodma formosa*, the eucosmodontid cf. *Essonodon* sp., the taeniolabidid cf. *Meniscoessus* sp., an indeterminate pelyomyid, the alphadontin *Alphadon marshi*, and the glabiid aff. *Glabius* sp. Taxa that have been removed, and are no longer considered part of the AWlf, include the iconic lambeosaurine *Parasaurolophus tubicen* and the chasmosaurine *Pentaceratops*, together with numerous other dinosaurs and non-mammalian vertebrates.

The Alamo Wash local fauna is dated to approximately 69 Ma based on correlation of *Alamosaurus sanjuanensis* to its occurrence in the Big Bend region of Texas, where it has been dated radioisotopically. This places the AWlf temporally before the Lancian LVA in the late-early Maastrichtian to earliest late Maastrichtian (late “Edmontonian”). There is no definitive evidence to support a Lancian or a Paleocene age for this vertebrate fauna.

### INTRODUCTION

Fossil vertebrates from the Upper Cretaceous rocks of the San Juan Basin have been collected and studied for more than a century. During this period the names, characterization, identity, and rank of the strata have changed, most notably for two of the rock units: the Kirtland and Ojo Alamo formations (Brown, 1910; Sinclair and Granger, 1914; Bauer, 1916; Reeside, 1924; Baltz, 1967; Fassett and Hinds, 1971; Fassett, 1973; Powell, 1973; Lucas and Sullivan, 2000b). The history of these stratigraphic interpretations and nomenclatural changes has been reviewed before and most recently summarized by Lucas and Sullivan (2000b). We use the stratigraphic nomenclature of Lucas and Sullivan (2000b) in this study (Fig. 1).

Lehman (1981) was the first to study the fossil vertebrates from the Naashoibito Member (Ojo Alamo Formation) in any comprehensive way. He coined the term “Alamo Wash local fauna” (AWlf) for the vertebrate fauna derived from the Naashoibito Member. However, he mistakenly included some taxa from the underlying strata (De-na-zin

Member of the Kirtland Formation) that are unique to the Willow Wash local fauna (WWlf) (Williamson and Sullivan, 1998; Williamson, 2000; Sullivan et al., 2005a,b; Sullivan and Lucas, 2006). In addition, some of the specimen identifications made by Lehman (1981) needed re-evaluation and this is done here.

In 1995, the State Museum of Pennsylvania (Harrisburg) launched a major field program to re-sample the fossil vertebrates from the Kirtland and Ojo Alamo formations in an attempt to more precisely document the biostratigraphic provenance of the faunas. This effort has resulted in a thorough faunal sampling of the Naashoibito Member that not only confirms some previous recorded occurrences, but has produced new and important vertebrate taxa. While the identifications and interpretations of the vertebrates from the Kirtland Formation (i.e., the Willow Wash local fauna) have, in part, been revised in recent studies, most notably those of Sullivan and Williamson (1995), Sullivan (1999), Sullivan and Lucas (2003b, 2006) and Carr and Williamson (2010), those of the Naashoibito Member (Alamo Wash local fauna) have not been updated. Here, we re-evaluate the vertebrate taxa and revise the faunal composi-

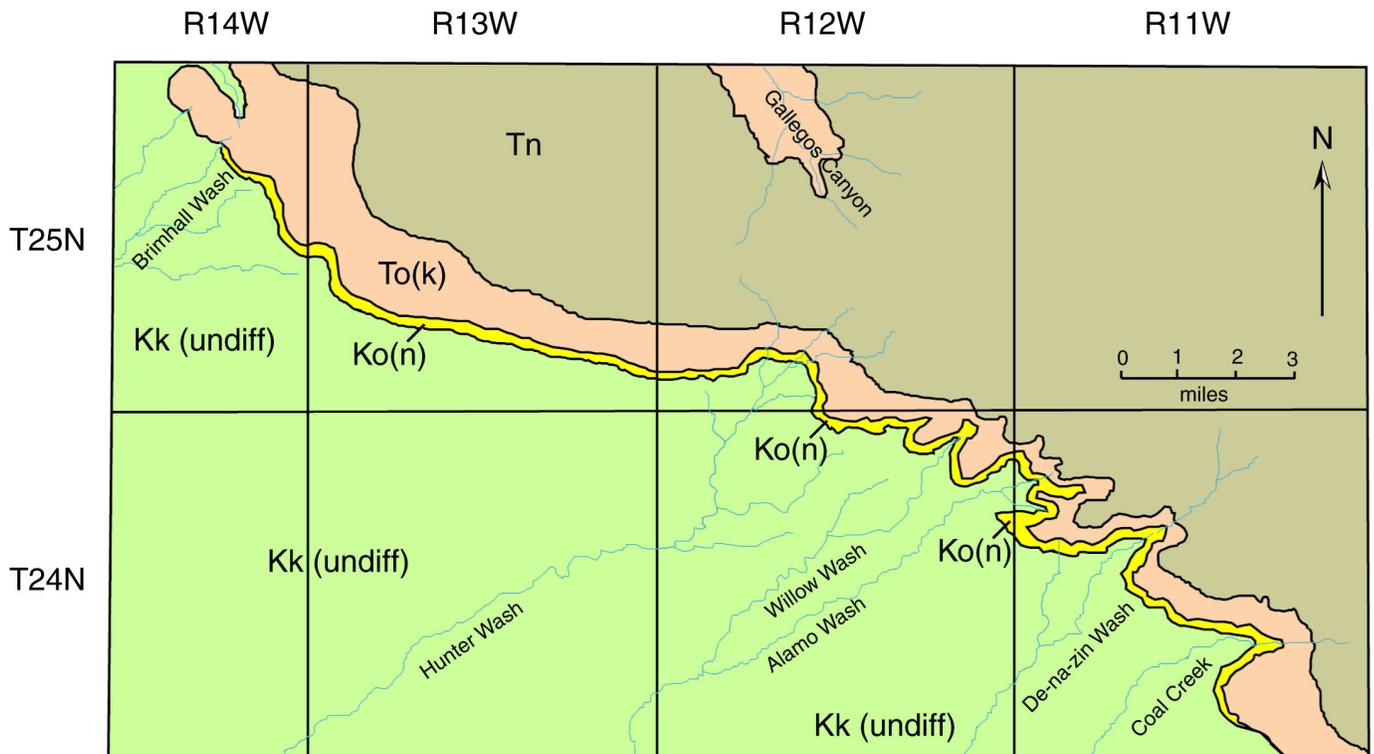


FIGURE 1. Geologic map showing the principle exposure of the Upper Cretaceous Ojo Alamo Formation, Naashoibito Member [**Ko(n)**]. Intermittent outcrops of the Naashoibito and Kimbeto [**To(k)**] members have been mapped to the southeast (Schneider et al., 1979; Lucas and Sullivan, 2000). **Additional abbreviations:** **Kk(undiff)** = Upper Cretaceous Kirtland Formation (undifferentiated), primarily the De-na-zin and Farmington members; and **Tn** = Tertiary (Paleocene) Nacimiento Formation. Map modified after Lehman (1985).

tion of the Alamo Wash local fauna, which is from the Upper Cretaceous Naashoibito Member of the Ojo Alamo Formation, San Juan Basin, New Mexico.

**Institutional Abbreviations:** **AMNH**, American Museum of Natural History, New York; **FMNH**, Field Museum of Natural History, Chicago; **NMMNH**, New Mexico Museum of Natural History and Science, Albuquerque; **SMP**, State Museum of Pennsylvania, Harrisburg; **USNM**, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

#### STRATIGRAPHIC CONTEXT

The Alamo Wash local fauna is the assemblage of fossil vertebrates collected from the Naashoibito Member of the Ojo Alamo Formation in the west-central San Juan Basin, primarily from the heads of Hunter, Willow, Alamo and De-na-zin washes (Fig. 1). Bauer (1916) introduced the lithostratigraphic name Ojo Alamo Sandstone for a tripartite unit - lower conglomerate, middle variegated “shale” and soft sandstone and upper conglomerate. Baltz et al. (1966) termed the lower and middle parts of the Ojo Alamo Sandstone the Naashoibito Member, and assigned that unit to the underlying Kirtland Shale. Powell (1973) named the upper part of the Ojo Alamo Sandstone the Kimbeto Member. We have dropped the lithologic descriptor sandstone, replacing it with formation, and regard the Ojo Alamo Formation to consist of two members, a lower Naashoibito Member and an upper Kimbeto Member (see Lucas and Sullivan, 2000b and Sullivan et al., 2005b for a detailed discussion of the lithostratigraphy of the Ojo Alamo Formation).

The Naashoibito Member of the Ojo Alamo Formation (e.g., Baltz et al., 1966; Lehman, 1981; Lucas and Sullivan, 2000b) is exposed only in the west-central San Juan Basin, between Brimhall Wash (T25N, R14W) and Bettonie Tsoie Wash (T22N, R9W) (Fig. 1). Outside of this area, the Ojo Alamo Formation is dominantly sandstone and conglomerate assignable to the Kimbeto Member.

The Naashoibito Member is as much as 30 m thick and consists of

a basal, extrasbasinal conglomerate overlain by variegated gray, olive gray, white, purple and maroon mudstone, siltstone and generally poorly-indurated sandstone. This slope-forming unit underlies the bench- and cuesta-forming Kimbeto Member, which is up to 20 m thick in the west-central San Juan Basin and consists mostly of brown, coarse-grained arkosic sandstone and extrasbasinal conglomerate with numerous fossil logs. The Naashoibito Member yields numerous fossil vertebrates, from at least 61 known localities (see Appendix), the Alamo Wash local fauna. Rare and evidently reworked dinosaur bones and bone fragments are the only fossil vertebrates known from the Kimbeto Member (Lucas, 1981; Fassett et al., 1987; Sullivan et al., 2005b).

#### SYSTEMATIC PALEONTOLOGY

##### Introduction

Here, we present a systematic review of the Alamo Wash local fauna, which is the fossil vertebrates known from the Naashoibito Member of the Ojo Alamo Formation, based primarily on fossils in the NMMNH and SMP collections. The Appendix lists the NMMNH and SMP locality numbers associated with the specimens listed here.

##### CHONDRICHTHYSES

##### ELASMOBRANCHII

##### Lamniformes Berg, 1958

##### Anacoracidae Casier, 1947

##### *Myledaphus* Cope, 1876

##### *Myledaphus* sp.

**Referred material:** NMMNH P-44485, isolated tooth.

**Remarks:** A single tooth (NMMNH P-44485), consisting of a six-sided crown with double roots, is identified as *Myledaphus* sp. Assuming that the geological horizon is correct, this specimen documents the presence of *Myledaphus* in the Alamo Wash local fauna. However, to

date, no other specimens of *Myledaphus* have been found in the Naashoibito Member. Numerous specimens of *Myledaphus* are known from the underlying De-na-zin Member (Kirtland Formation) and the purported Naashoibito record may have originated from that stratum. However, *Myledaphus* has been reported in the Lance Formation of Wyoming (Estes, 1964), so its presence in the Naashoibito Member is not implausible.

**Orectolobitormes Applegate, 1972**  
**Orectolobidae Jordan and Fowler, 1903**  
*Squatirhina* Casier, 1947  
 ?*Squatirhina* sp.

**Referred material:** NMMNH P-27832, isolated tooth.

**Remarks:** An isolated tooth, NMMNH P-27832, identified as ?*Squatirhina*, may represent the first and only record of this taxon from the Naashoibito Member. *Squatirhina* is distinguished by irregular ridges running radially on the ventral portion of the tooth and the irregular geometric outline of the ventral surface of the tooth. However, the identification of NMMNH P-27832 could not be confirmed by us because the specimen was unavailable for study, so its identity is questionable.

**OSTEICHTHYES**  
**ACTINOPTERYGII**  
**Holostei Müller, 1844 (*sensu* Grande, 2010)**  
**Lepisosteidae Cuvier, 1825**  
**Lepisosteidae indet.**

**Referred material:** SMP VP-2068, isolated scale; SMP VP-2501, isolated scale; SMP VP-2782, isolated scale; SMP VP-2858, isolated scale.

**Remarks:** Isolated, lozenge-shaped ganoid fish scales were first reported from the Ojo Alamo Sandstone by Gilmore (1916) and later by Lehman (1981) from the Naashoibito Member. Gilmore (1916, p. 302) noted *Lepisosteus* from two generalized localities in the Barrel Springs region above the lower conglomerate (= base of Naashoibito Member). Wiley (1976) documented that isolated “gar” scales are not generically diagnostic, so it may be that these specimens pertain to *Lepisosteus*, *Atractosteus*, or another genus. Brinkman (2005) conservatively considered all gar scales from the Dinosaur Park Formation to be tentatively *Lepisosteus*. We follow Grande’s (2010) more conservative identifications for similar Upper Cretaceous gar scales and refer those from the Naashoibito Member to *Lepisosteidae* indet.

**AMPHIBIA**  
**Caudata**  
**Batrachosauroididae Auffenberg, 1958**  
 ?*Batrachosauroididae* indet.

**Referred material:** NMMNH P-44917, incomplete vertebra.

**Remarks:** Weil et al. (2004) briefly mentioned remains of a salamander (NMMNH P-32992) without providing a description or illustration. We were unable to study this specimen so their identification cannot be confirmed at this time. We identify NMMNH P-44917 as a trunk vertebra and questionably assign it to the ?*Batrachosauroididae* based on the overall morphological similarity to *Opisthotriton*-like specimens described by Estes (1981).

**TESTUDINES**  
**Paracryptodira Gaffney, 1975**  
**Pleurosternidae Cope, 1868**  
*Compsemys* Leidy, 1856  
*Compsemys* sp.  
 Fig. 2C-F

**Referred material:** SMP VP-2527, two carapace fragments; SMP

VP-2590, carapace and plastron fragments (Fig. 2C-F); USNM 8349, four carapace fragments and plastron/bridge fragment.

**Remarks:** Gilmore (1916) recognized the similarity to *Compsemys vafer* in the surface texture (small, round pustules) of the carapace and plastron fragments of USNM 8349. The precise stratigraphic horizon for this specimen was not provided by Gilmore (1916), but the recovery of additional specimens confirms the presence of *Compsemys* in the Naashoibito Member. SMP VP-2590 (Fig. 2C-F) comprises carapace and plastron fragments that show distinct sculpturing consisting of fine tubercles, and is indicative of the genus *Compsemys*, although species level identification is not possible. Lehman (1981) listed *Compsemys* sp., as did Hunt and Lucas (1993) as part of the AWlf, presumably based on Gilmore (1916).

**Paracryptodira indet.**  
**Fig. 3E**

**Referred material:** SMP VP-2670, incomplete carapace fragment (Fig. 3E).

**Remarks:** SMP VP-2670, a carapace fragment, has very fine, small tubercles and faint ridges (Fig. 3E). It represents an indeterminate paracryptodiran based on shell morphology similar to *Compsemys*, but the specimen cannot be confidently assigned to any specific family within Paracryptodira.

**Baenidae Cope, 1882**  
**Baenidae indet.**  
**Fig. 2A-B**

**Referred material:** SMP VP-2482, carapace fragment; SMP VP-2506, peripheral carapace fragment; SMP VP-2513, incomplete right hypoplastron (Fig. 2A-B); SMP VP-2594, carapace fragment; SMP VP-2637, neural and associated carapace fragments; SMP VP-3259, carapace fragment.

**Remarks:** Specimens assigned to Baenidae indeterminate consist mostly of shell (carapace and plastron) fragments. The only plastron fragment, SMP VP-2513 (Fig. 2A-B), has little surface texture and is identified as an indeterminate baenid based on overall morphological similarities to other baenid specimens. “*B.*” *nodosa*, now known as *Denazinemys nodosa* (Lucas and Sullivan, 2006), was listed by Lehman (1981) and Hunt and Lucas (1993) as present in the Alamo Wash local fauna. The holotype specimen (USNM 8345) is actually from the underlying De-na-zin Member of the Kirtland Formation, and its occurrence in the AWlf has not been demonstrated.

*Neurankylus* was reported from the Naashoibito Member of the Ojo Alamo Formation (Wiman, 1933) and listed by Lehman (1981) as a part of the AWlf. However, Mateer (1981) correctly identified Wiman’s *Neurankylus* specimen as coming from the lower part of the Kirtland Formation (Hunter Wash Member) at the head of Ah-shi-sle-pah Wash. Therefore, *Neurankylus* is not known from the Ojo Alamo Formation. Gaffney (1972) synonymized *N. baueri* Gilmore with *N. eximius*, but Sullivan et al. (in press) recognize *N. baueri* as a distinct and valid species. *N. baueri* is known only from the San Juan Basin. PMU.R26 (Exemplar 3 of Wiman, 1933) consists of the greater posterior section of a carapace and plastron, and is identified as *Neurankylus baueri* (Sullivan et al., in press). The specimen purportedly came from “between the conglomerates [of the] Ojo Alamo Sandstone” (Wiman, 1933). However, the preservation of PMU.R26 is inconsistent with that of fossils found in the Naashoibito Member, and, based on its carmel brown color and preservation, we believe it to be from the Hunter Wash Member of the Kirtland Formation. Another specimen, PMU.R28, identified as *Neurankylus* sp., presumably came from the “Ojo Alamo Formation *sensu lato*” (Wiman, 1933), and has the same color and preservation as PMU.R26. Both specimens are now considered to be from the Kirtland Formation (Sullivan et al., in press). We note though that *Neurankylus* is present in the overlying Paleocene Nacimiento Formation (Sullivan et al.,

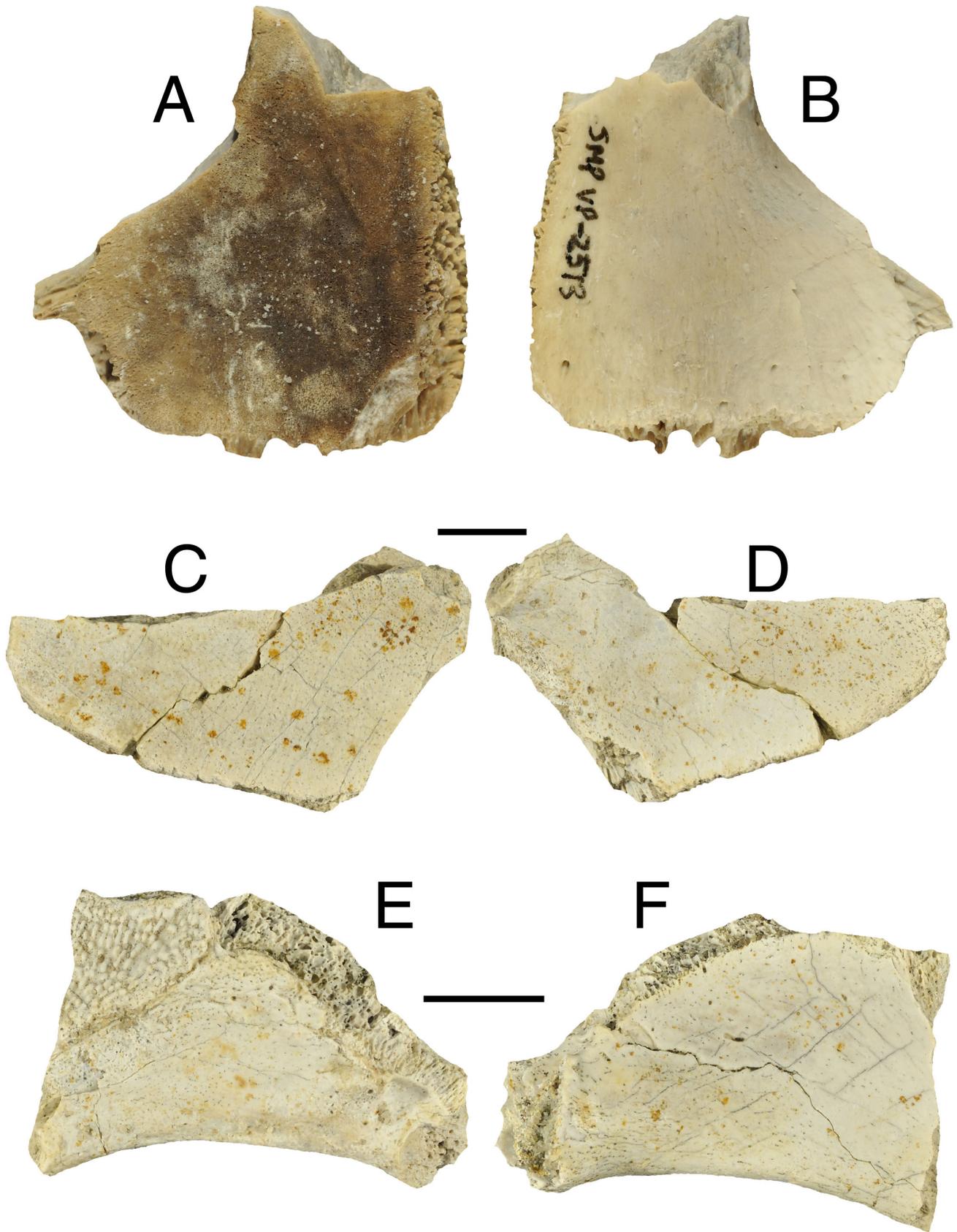


FIGURE 2. Baenidae and *Compsemys*. A-B, SMP VP- 2513, Baenidae indeterminate, incomplete right hypoplastron in A, external and B, internal views. C-F, SMP VP-2590, *Compsemys* sp., C-D, carapace fragment in C, external and D, internal views, and E-F, plastron fragment in E, external and F, internal views. Bar scales = 1 cm.

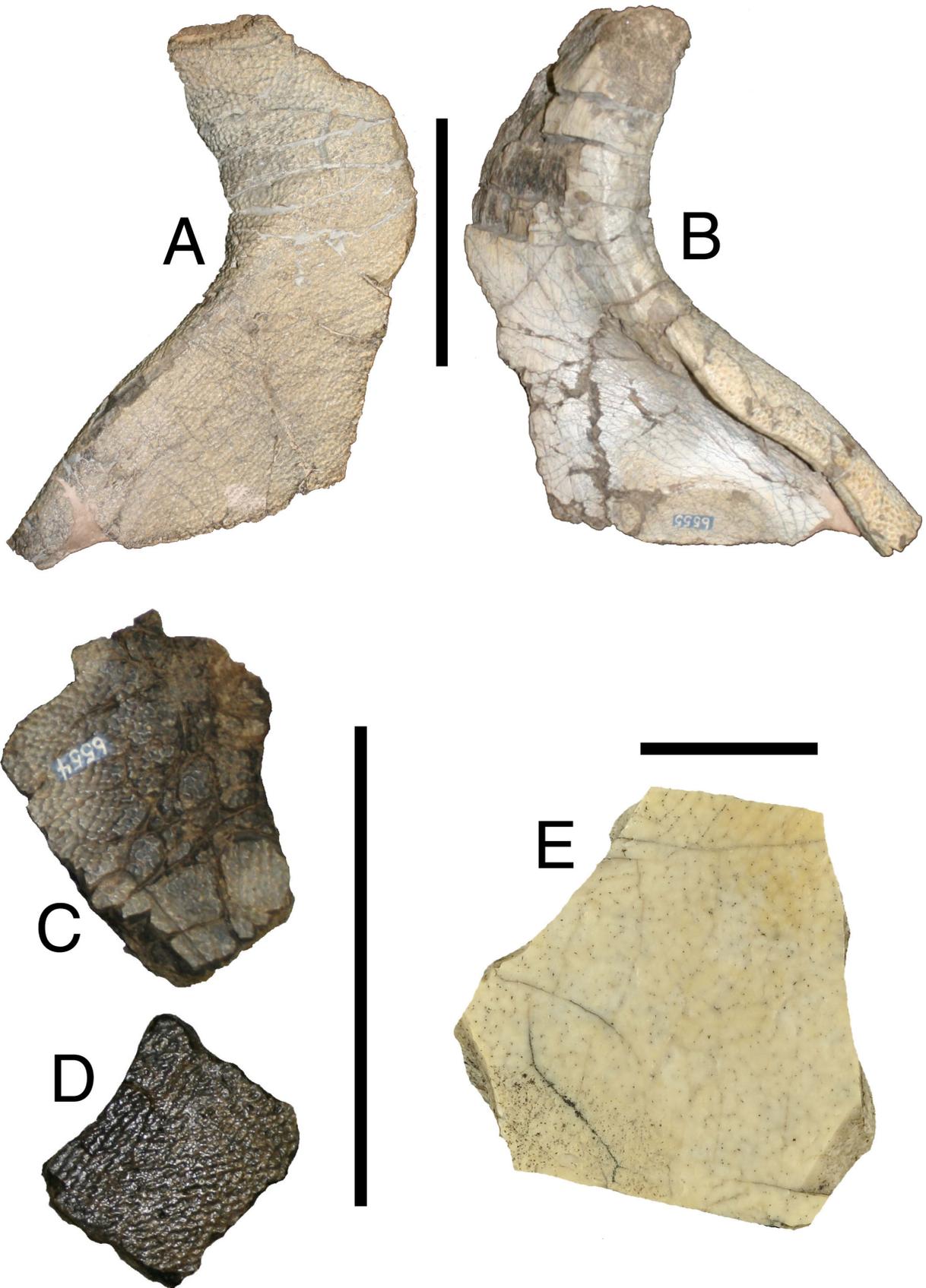


FIGURE 3. *Basilemys*, Adocidae, Paracryptodira. **A-B**, USNM 6555 (holotype of *Basilemys nobilis*, in part), *Basilemys* sp., incomplete hypoplastron in **A**, external and **B**, internal views. **C-D**, USNM 6554 (holotype of *Adocus vigoratus*, in part), Adocidae indeterminate, plastron fragments in external view. **E**, SMP VP-2670, Paracryptodira indeterminate, carapace fragment in dorsal view. Bar scales **A-D** = 10 cm; **E** = 1 cm.

1988), so we expect that it may be found in the Naashoibito Member in the future.

The holotype of *Thescelus rapiens* (AMNH 6066) purportedly came from the “Laramie deposits, at Ojo Alamo, San Juan County, New Mexico,” the same locality as *Kritosaurus navajovius*, which is now known to be from the De-na-zin Member of the Kirtland Formation (Sullivan et al., in press). *T. insiliens* was demonstrated to be a junior synonym of *T. hemispherica* by Gaffney (1972) and was later listed by Lehman (1981) as a taxon of the Alamo Wash local fauna. *Thescelus rapiens* and *T. insiliens* were then tentatively synonymized with *T. hemispherica* by Sullivan and Lucas (2006). Sullivan et al. (in press) concluded that both *T. hemispherica* and *T. rapiens* could not be synonymized with *T. insiliens*, and they are retained as three distinct species. Regardless, *Thescelus* has been collected only in the Hunter Wash and De-na-zin members of the Kirtland Formation (Sullivan et al., in press) and thus it is not part of the AWlf.

#### ?Kinosternidae Hay, 1892

##### *Hoplochelys* Hay, 1908

##### *Hoplochelys* sp.

##### Fig. 4A-E

**Referred material:** NMMNH P-29159 (= UNM FKK-002), complete entoplastron (Fig. 4C); SMP VP-1571, nuchal; SMP VP-1578, nuchal (Fig. 4A-B); SMP VP-1650, left hypoplastron (Fig. 4D-E); SMP VP-2109, plastron fragment; SMP VP-2514, two carapace fragments.

**Remarks:** Lehman (1981) identified and illustrated NMMNH P-29159 (= UNM FKK-002) as an entoplastron of *Hoplochelys* cf. *H. bicarinata* (Fig. 4C) based on similarity to USNM 8524 figured by Gilmore (1919, p. 43-47, text-fig. 17) from the Paleocene “Puerco Formation” (= Nacimiento Formation). Since Lehman’s paper, a few additional ?kinosternid specimens have been recovered from the Naashoibito Member and are here identified as *Hoplochelys* sp. These specimens include nuchals (SMP VP-1571 and VP-1578), a left hypoplastron (SMP VP-1650), a plastron fragment (SMP VP-2109) and two carapace fragments (SMP VP-2514). The nuchals are identified as *Hoplochelys* sp. based on their distinctive dorsal morphology, characterized by a lower posterodorsal surface with a ridge running through the middle of it anteroposteriorly (see Fig. 4A). SMP VP-1650, a left hypoplastron, is identified as *Hoplochelys* sp. based on lacking a medial contact of the abdominals (Fig. 4D-E). The carapace fragments (SMP VP-2514) have a fine shagreened surface texture, which is characteristic of the genus (Gilmore, 1919). These additional specimens confirm the presence of *Hoplochelys* sp. as a component of the AWlf.

#### Adocidae Cope, 1870

##### Adocidae indet.

##### Fig. 3C-D

**Referred material:** USNM 6554 (holotype of *Adocus vigoratus*), first neural, first left peripheral, seventh left peripheral, section of carapace from the free border to the border that articulated with the free costal, section of the free border of the base of the hind lobe (Fig. 3C-D); SMP VP-1308, carapace fragments; SMP VP-2356, carapace fragment; SMP VP-2389, carapace fragments; SMP VP-2663, carapace fragments; SMP VP-2785, carapace marginal fragment.

**Remarks:** The holotype of *Adocus vigoratus* (USNM 6554, Fig. 3C-D), was collected by Barnum Brown from “below the upper bed of conglomerate, in those beds which furnished remains of dinosaurs” (Hay, 1911). This suggests the specimen was recovered from above the lower conglomerate and, therefore, within the Naashoibito Member. The specimen consists of fragmentary portions of the carapace and plastron, most notably the first neural, peripherals and right xiphiplastron. The specimen lacks any diagnostic generic or specific characters, thus we consider *A. vigoratus* a *nomen dubium* due to the undiagnostic nature of the holotype (USNM 6554) and designate it an indeterminate adocid. Sev-

eral other fragments in the SMP collection are also referred to indeterminate adocids, based on their carapace surface texture.

#### Nanhsiungchelyidae Yeh, 1966

##### *Basilemys* Hay, 1902

##### *Basilemys* sp.

##### Fig. 3A-B

**Referred material:** USNM 6555 (holotype of *Basilemys nobilis*), fragments of the carapace and plastron, including portions of the hypoplastron and the xiphiplastron (Fig. 3A-B).

**Remarks:** The holotype of *Basilemys nobilis* (USNM 6555, Fig. 3A-B) purportedly came from “below the upper conglomerate bed, in the dinosaur-bearing deposits and about 50 feet above the lower conglomerate” (Hay, 1911, p. 316). This indicates that it is from the Naashoibito Member. The taxon is now considered a *nomen dubium* by Sullivan et al. (in press), who argue the type material is not diagnostic at the species level and cannot be distinguished from other species of *Basilemys* (*B. variolosa*, *B. praeclara* and *B. sinuosa*). The ornamentation of the carapace and plastron of *Basilemys* is very distinctive, so there is no question regarding its generic identity. It would appear that *Basilemys* is present in the Alamo Wash local fauna, assuming that the original stratigraphic description is correct. We note, however, that no additional material of this genus has been recovered by either NMMNH or SMP from the Naashoibito Member over the last two decades of collecting, which suggests that it may have originated from below the Naashoibito. We tentatively retain *Basilemys* sp. as a member of the AWlf.

#### Trionychidae Gray, 1825

##### *Plastomenus* Cope, 1873

##### cf. *Plastomenus* sp.

##### Fig. 5A

**Referred material:** SMP VP-2517, nearly complete right parietal (Fig. 5A).

**Remarks:** The anterior part of a right parietal (SMP VP-2517) measures 4.0 cm along the sutural surface, 1.5 cm wide at the anterior end, perpendicular to the sutural surface, and has a maximum thickness of 2.0 cm (Fig. 5A). The anterior part of the parietal makes up the posterior portion of the orbit, and compares readily to that of *Plastomenus thomasi* (AMNH 6015) illustrated by Gaffney (1979, text-fig. 183, p. 279). Based on the parietal forming part of the posterior portion of the orbit, we refer SMP VP-2517 to cf. *Plastomenus* sp.

#### Trionychidae indet.

##### Fig. 4F-G, 5B-E

**Referred material:** SMP VP-1096, incomplete left femur; SMP VP-1307, indeterminate carapace fragment; SMP VP-1309, carapace fragment; SMP VP-1310, unidentified carapace fragments; SMP VP-1572, incomplete scapula; SMP VP-1577, indeterminate fragment of carapace; SMP VP-1713, nearly complete costal (Fig. 4F-G); SMP VP-1834, carapace fragment; SMP VP-1988, incomplete costal; SMP VP-1998, carapace fragment; SMP VP-1999, carapace fragment; SMP VP-2031, small fragment of carapace; SMP VP-2078, two carapace fragments; SMP VP-2173, indeterminate carapace fragment; SMP VP-2234, unidentified portion of carapace; SMP VP-2260, portions of the carapace; SMP VP-2433, two carapace fragments; SMP VP-2436, unidentified fragment of carapace; SMP VP-2447, incomplete left lateral end of hypoplastron; SMP VP-2452, multiple parts of carapace; SMP VP-2515, portions of carapace; SMP VP-2664, portions of the carapace; SMP VP-2665, indeterminate parts of carapace; SMP VP-2666, carapace fragments; SMP VP-2667, carapace fragments; SMP VP-2668, unidentified carapace fragment; SMP VP-2669, fragment of carapace; SMP VP-2672, carapace fragment; SMP VP-2673, indeterminate part of carapace; SMP VP-2674,

multiple parts of carapace; SMP VP-2694, costal marginal carapace fragment; SMP VP-2697, costal; SMP VP-2783, unidentified carapace fragments with associated bone material; SMP VP-2810, one lateral hypoplastron fragment and one ?hypoplastron fragment (Fig. 5B-E); SMP VP-3256, two carapace fragments; SMP VP-3260, carapace fragment.

**Remarks:** Numerous trionychnid specimens have been recovered from the Naashoibito Member over the last two decades. Unfortunately, much of this material is fragmentary and defies generic identification. Various trionychoid and trionychnid taxa have been reported from the Fruitland, Kirtland and Ojo Alamo formations (Hay, 1908; Gilmore, 1916, 1919, 1946; Lehman, 1981; Hunt and Lucas, 1993). Sullivan et al. (in press) considered the three species *Aspideretoides fontanus*, *A. austerus*, and *A. vorax*, previously *Aspideretes* (see Gardner et al., 1995), to be a single taxon that they recognize as *A. austerus*. Although the holotypes of *A. fontanus* and *A. austerus* had been considered to be from the “Laramie/Ojo Alamo beds,” the bluish gray preservation with concretionary hematite clumps that cover parts of the three type specimens suggest these specimens originated from the underlying De-na-zin Member (Sullivan et al., in press). Therefore, neither the species *A. austerus*, nor the genus *Aspideretoides*, is known to occur in the Naashoibito Member. Fragmentary trionychnid shell material, such as SMP VP-1713 (Fig. 4F-G, 5B-E), and postcranial material (SMP VP-1572, an incomplete scapula) is difficult to identify to the generic, let alone specific, taxonomic level with certainty. We regard all the trionychnid material as undiagnostic with the exception of the parietal (SMP VP-2517), which we refer to cf. *Plastomenus* sp. above.

#### Testudines indet.

**Referred material:** SMP VP-2518, four indeterminate shell fragments; SMP VP-2671, unidentified carapace fragment.

**Remarks:** SMP VP-2518 and VP-2671 are shell fragments that are not identifiable below the taxonomic level of Testudines because of their fragmentary nature and lack of diagnostic surface texture.

#### SQUAMATA

##### Teiidae Gray, 1827

##### *Chamops* Marsh, 1892

##### ?*Chamops* sp.

**Referred material:** NMMNH P-15017 (= UNM FKK-036), tooth.

**Remarks:** Lehman (1981) identified NMMNH P-15017 as the pharyngeal tooth of a cyprinid fish. It has been re-identified as the teiid lizard *Chamops* sp. However, this identification has not been confirmed by us because it was not available for study, so its presence in the Alamo Wash local fauna is considered questionable. Sullivan (1981) identified UNM FKK-038a, a fragmentary right dentary from the Fruitland Formation, as cf. *Chamops segnis*. We note that *Chamops* is known from the younger Lance Formation of Wyoming (Estes, 1964), and an earlier occurrence may be possible. It is doubtful that a generic assignment can be based solely on a single tooth. If it is in fact a teiid, an identification of Teiidae indeterminate may be more accurate, if it cannot be assigned to the teiid *Peneteius*.

##### *Peneteius* Estes, 1969

##### *Peneteius* sp.

**Referred material:** NMMNH P-36544, jaw fragment with tooth; NMMNH P-41233, lower tooth; NMMNH P-41224, upper tooth.

**Remarks:** In separate abstracts, Weil et al. (2004) and Williamson and Weil (2004) reported on specimens of the teiid lizard *Peneteius* from the Naashoibito Member. However, these identifications cannot be verified until the specimens have been properly documented. While *Peneteius* is known from the late Maastrichtian of Montana, it is also known from

the Campanian of Utah and Texas (Weil et al., 2004; Williamson and Weil, 2004), making it a temporally long-ranging taxon. We tentatively accept it as component of the AWlf, pending documentation.

#### CROCODYLIA

##### Alligatoridae Gray, 1844

##### *Brachychampsia* Gilmore, 1911

##### cf. *Brachychampsia* sp.

##### Fig. 6I-J

**Referred material:** SMP VP-2504, mandibular or maxillary molariform tooth (Fig. 6I-J).

**Remarks:** A single isolated molariform tooth (SMP VP-2504; Fig. 6I-J) is consistent with other molariform teeth known in the Late Cretaceous alligatorid taxon *Brachychampsia*. Previously, Lehman (1981) identified a number of “small, low-crowned, ‘button-shaped’ teeth-elongate and subovate in occlusal view” from the Naashoibito Member as belonging to *Allognathosuchus*, but considered the identity of these teeth as questionable. *Allognathosuchus* is known with certainty only from the overlying Paleocene deposits in the San Juan Basin, and is considered a Paleocene-Eocene taxon (Lucas and Estep, 2000). Lucas (1992) suggested that such Upper Cretaceous “button-shaped” teeth are probably *Brachychampsia*, a Late Cretaceous taxon known from Montana (Gilmore, 1911) and New Mexico (Gilmore, 1916; Sullivan and Lucas, 2003b). Thus, these isolated molariform crocodylian teeth from the Naashoibito Member are tentatively referred to cf. *Brachychampsia* sp.

##### Crocodylidae Cuvier, 1807

##### Crocodylidae indet.

##### Fig. 6A-H, K-N

**Referred material:** NMMNH P-25022 (= UNM B-675), isolated tooth; NMMNH P-32838, mandibular fragment (Fig. 6M-N); SMP VP-1321, osteoderm (Fig. 6A); SMP VP-1823, complete osteoderm (Fig. 6B); SMP VP-2049, isolated tooth (Fig. 6G-H); SMP VP-2503, isolated tooth (Fig. 6K-L); SMP VP-2511, mandibular osteoderm (Fig. 6C-D); SMP VP-2787, isolated tooth (Fig. 6E-F).

**Remarks:** Crocodylians are not common in the Naashoibito Member. Gilmore (1916, p. 289) reported on two specimens from two separate localities in the Ojo Alamo Formation, one consisting of teeth and a dermal scute from locality no. 67 of Bauer (1916), and the other, a single tooth from locality no. 63 of Bauer (1916). Lucas (1992) considered this material to be *Leidyosuchus*, a common Late Cretaceous crocodylian with long, conical, carinate teeth. Lehman (1981, text-fig. 9.15) illustrated a tooth (NMMNH P-25022 = UNM B-675) he identified as “*Goniopholis*” and reported on several additional teeth as having regularly-spaced longitudinal costae similar to a tooth from the Kirtland Shale figured by Wiman (1932, pl. 5, fig. 2, 3) as “*Goniopholis*” (now *Denazinosuchus*: Lucas and Sullivan, 2003), an identification accepted by Lucas (1992). We identify this tooth as an indeterminate crocodylid because none of the features are diagnostic to a particular genus. *Denazinosuchus kirtlandicus* is from older strata (De-na-zin Member, Kirtland Formation) in the San Juan Basin (Lucas and Sullivan, 2003), and is not considered part of the AWlf.

Three different morphotypes of crocodylid teeth are present in the Naashoibito Member, including those that are slightly wide and straight (SMP VP-2787, Fig. 6E-F), those that are very thin, gracile, and relatively long (SMP VP-2503, Fig. 6K-L), and those that are relatively large, robust, and slightly curved (SMP VP-2049, Fig. 6G-H). All three tooth morphotypes have regularly-spaced, longitudinal costae but are not all necessarily from three different taxa. Sullivan and Lucas (2003a) noted different tooth morphologies in the dentaries, premaxillae and maxillae of *Brachychampsia montana* (from the De-na-zin Member, Kirtland Formation), indicating that generic and specific identification based on isolated teeth is not possible. Indeterminate crocodylid

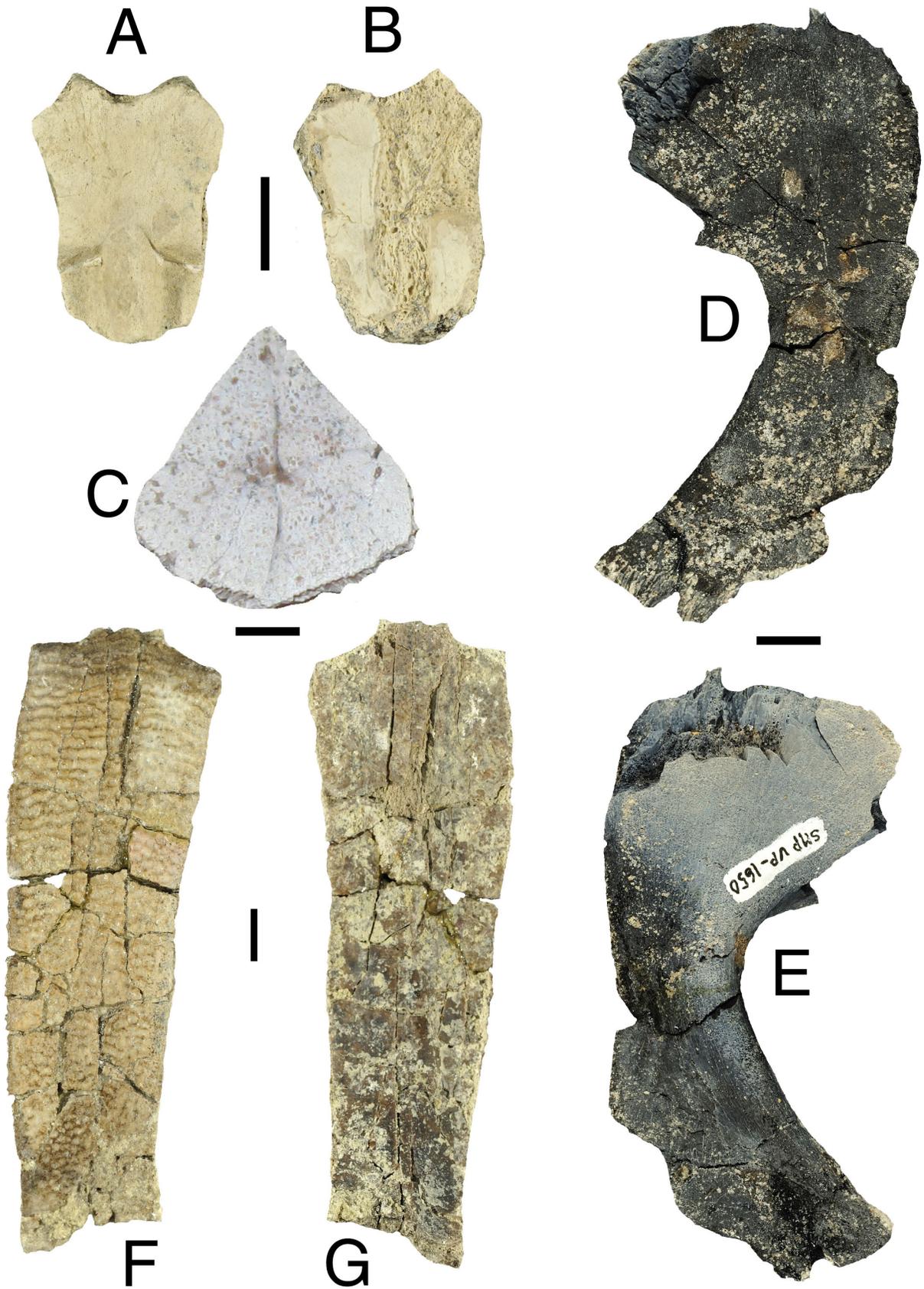


FIGURE 4. *Hoplochelys* and Trionychidae. **A-B**, SMP VP-1578, *Hoplochelys* sp., nuchal in **A**, external and **B**, internal views. **C**, NMMNH P-29159 (previously UNM FKK-002), *Hoplochelys* sp., entoplastron in external view. **D-E**, SMP VP-1650, *Hoplochelys* sp., left hypoplastron in **D**, external and **E**, internal views. **F-G**, SMP VP-1713, Trionychidae indeterminate, nearly complete costal in **F**, external and **G**, internal views. Bar scales = 1 cm.

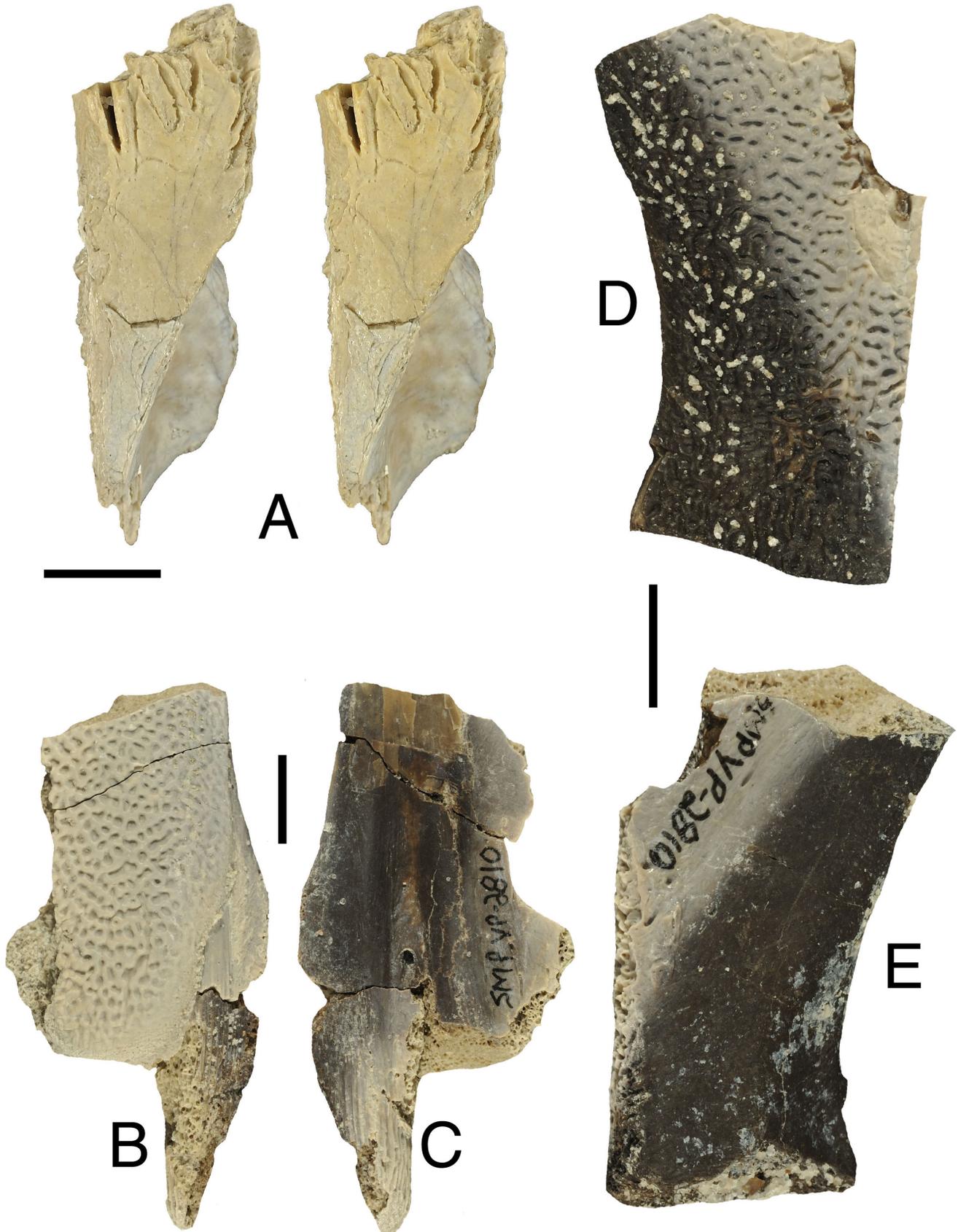


FIGURE 5. Trionychidae. A, SMP VP-2517, cf. *Plastomenus* sp., nearly complete right parietal in dorsal view (stereo). B-E, SMP VP-2810, Trionychidae indeterminate, ?hypoplastron distal end in B, external and C, internal views; medial edge in D, external and E, internal view. Bar scales = 1 cm.

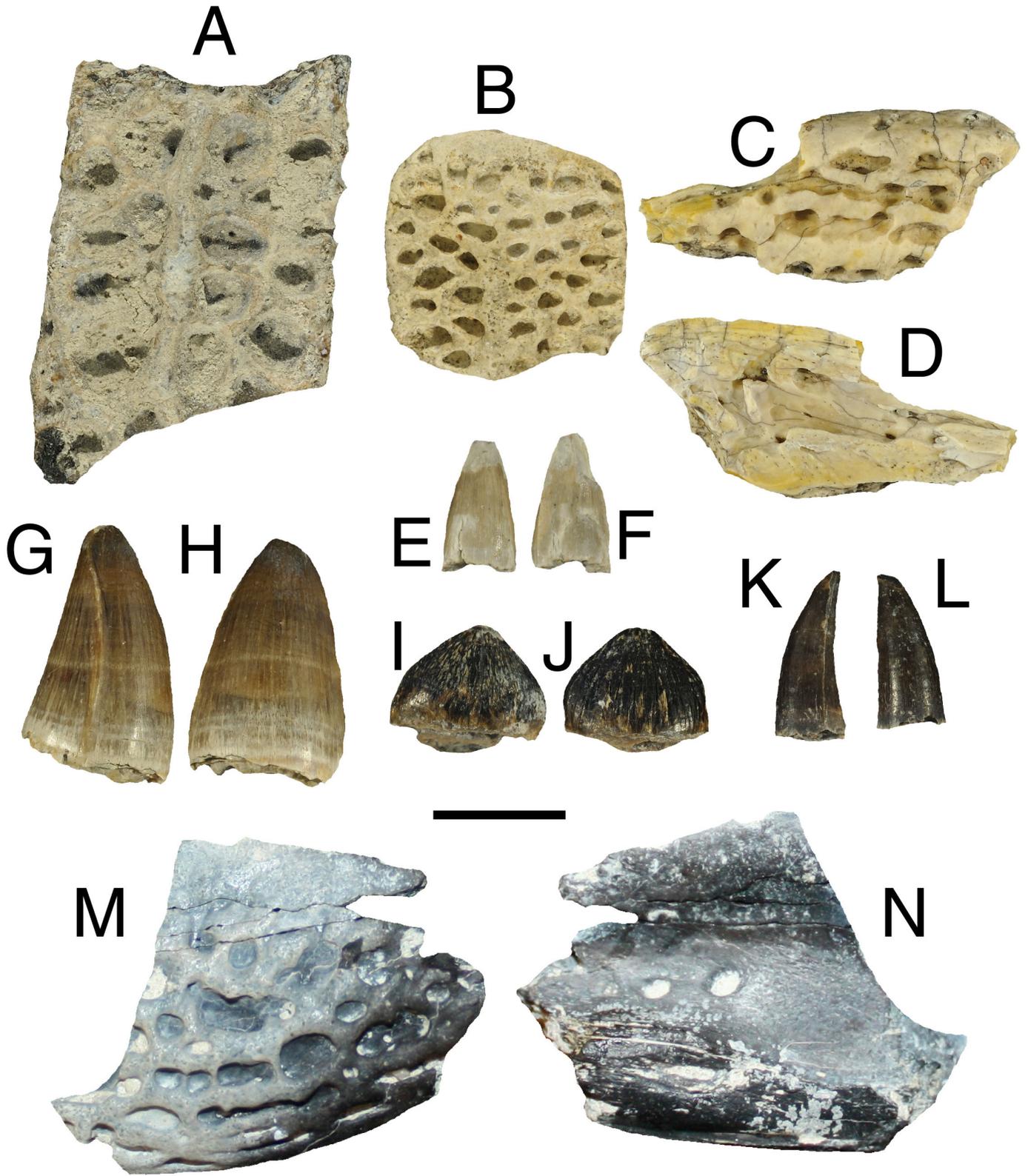


FIGURE 6. Crocodylia and cf. *Brachychampsia* sp. Crocodylia indeterminate, osteoderms in dorsal view: **A**, SMP VP-1321 and **B**, SMP VP-1823. Mandibular osteoderms: **C-D**, SMP VP-2511, ?mandibular dermal armor fragment in **C**, external and **D**, internal views; and NMMNH P-32838, **M**, external and **N**, internal views. Conical teeth in various views: **E-F**, SMP VP-2787; **G-H**, SMP VP-2049; and **K-L**, SMP VP-2503. **I-J**, SMP VP-2504, cf. *Brachychampsia* sp., mandibular or maxillary tooth in **I**, medial and **J**, lateral view. Bar scale = 1 cm.

osteoderms from the mandibular region include NMMNH P-32838 (Fig. 6M-N) and SMP VP-2511 (Fig. 6C-D), both bearing irregular-shaped pits and ridges. Two other osteoderm specimens, SMP VP-1321 (Fig. 6A) and VP-1823 (Fig. 6B), have more oval and circular-shaped pits.

## DINOSAURIA

### Saurischia Seeley, 1888

#### Theropoda Marsh, 1881

#### Coelurosauria incertae sedis Huene, 1914

#### *Richardoestesia* Currie, Rigby and Sloan, 1990

#### *Richardoestesia* sp.

**Referred material:** NMMNH P-32742, isolated tooth.

**Remarks:** In a series of abstracts, Weil and Williamson (2000), Williamson and Weil (2001a, 2001b) and Williamson et al. (2003) reported the occurrence of *Richardoestesia* from the Naashoibito Member. We have not seen the specimens upon which this identification has been based so we are unable to verify the presence of this taxon in the AWf.

#### Tyrannosauroida Walker, 1964

#### Tyrannosauridae Osborn, 1905

#### Tyrannosauridae indet.

#### Figs. 7-8

**Referred material:** AMNH 5882, right pedal phalanx; NMMNH P-7199, partial left dentary, tooth fragments, and partial vertebra; SMP VP-1113, incomplete right femur; SMP VP-1317, incomplete tip of tooth; SMP VP-1574, nearly complete tooth (Fig. 8A-B); SMP VP-1848, left metatarsal 1 (Fig. 7C-D); SMP VP-2105, nearly complete right scapulocoracoid (Fig. 7A-B); SMP VP-2174, tip of tooth, associated with indeterminate bone fragment; SMP VP-2352, lateral half of tooth (Fig. 8C-D).

**Remarks:** A few cranial and postcranial specimens can be assigned to Tyrannosauridae based on morphology. Postcranial remains include SMP VP-1113, a badly weathered right femur (Lucas and Sullivan, 2000b, fig. 5E) and SMP VP-1848, the 1st phalanx of the 1st metatarsal (Fig. 7C-D) that are from a large tyrannosaurid that seems more gracile than an adult *Tyrannosaurus rex*, although they may represent a juvenile or sub-adult. The scapulocoracoid (SMP VP-2105, Fig. 7A-B) may be from an adult as it compares readily in size and morphology to the scapulocoracoids of *Tyrannosaurus rex* (FMNH PR2081; Brochu, 2003, fig. 80). While this indicates the presence of a large tyrannosaurid in the Naashoibito Member, the specimen cannot be confidently referred to *Tyrannosaurus rex*, but may represent *Tyrannosaurus* sp. A large pedal phalanx of a tyrannosaur (AMNH 5882) purportedly came from the Naashoibito Member (Carr and Williamson, 2000, fig. 4A-F).

A few complete and incomplete tyrannosaurid teeth have been recovered from the Naashoibito Member. These vary in size and form, from conical (SMP VP-1574, Fig. 8A-B) to laterally compressed (SMP VP-2352, Fig. 8C-D). Both teeth have denticle densities of 7-8 denticles per 5 mm, similar to ranges seen in teeth of *Tyrannosaurus rex* (6-9 denticles per 5 mm) (Lehman, 1981; Carr and Williamson, 2000), although the two are very different in overall length (6.1 cm and 10.5 cm, respectively). SMP VP-1317, an incomplete tip of tooth, bearing remnants of denticles, also has a count of 7-8 denticles per 5 mm. SMP VP-2174 consists of the tip of a laterally-compressed tooth and has 9-10 denticles per 5 mm, which places it in the upper range of *Tyrannosaurus* and the lower ranges of several smaller tyrannosauroids (Carr and Williamson, 2000). Another specimen, SMP VP-3334, is a large, incomplete basal part of a tooth. It is partly concreted so the denticles are covered and a density count is not possible.

NMMNH P-7199 consists of a badly-weathered partial left dentary, tooth fragments, and a partial vertebra of a tyrannosaurid from the Naashoibito Member and was referred to cf. *Tyrannosaurus rex* by Carr and Williamson (2000) based on denticle density. However, identi-

fication below the family level (Tyrannosauridae) based on denticle densities is tenuous (Carr and Williamson, 2000).

Gilmore (1916, p. 288) reported the remains of large carnivorous dinosaurs from the Ojo Alamo Formation. He cited a "tooth of large carnivorous dinosaur" and "teeth of carnivorous dinosaurs," as coming 10-11 feet above the base of the lower conglomerate (Gilmore, 1916). He tentatively referred the large theropod material to "*Deinodon*?" (Gilmore, 1916). Gilmore (1919) also noted a few fragmentary vertebrae of a very large carnivorous dinosaur collected by J.B. Reeside Jr. from "3 to 8 feet above the base of the Ojo Alamo formation," or approximately the same locality as the teeth he earlier reported on in 1916 (Gilmore, 1919). These were the first specimens to indicate the presence of a large carnivorous dinosaur with the proportions of *Tyrannosaurus* in the Ojo Alamo Formation (Gilmore, 1919). Unfortunately, no specimen numbers were cited, and the specimens were too fragmentary to be properly identified (Gilmore, 1919). The disposition of the specimens is unknown (Carr and Williamson, 2000).

Lehman (1981, p. 208, text-fig. 9.6) mentioned and illustrated a right metatarsal IV (in the private collection of R.P. Ratkevich) and tentatively referred it to "*?Albertosaurus* sp." We cannot comment further on the specimen. Lehman (1981) stated that there are a large number of isolated (shed) tyrannosaurid teeth currently in the NMMNH collection that are also referable to "*?Albertosaurus* sp." based on the number of denticles per 5 mm (Lehman, 1981). The basis for this identification was the idea that denticles normally range from about 9-15 per 5 mm for *Albertosaurus* and *Daspletosaurus*, and from about 6-9 per 5 mm for *Tyrannosaurus* (Lehman, 1981). However, Carr and Williamson (2000) stated that identification based on denticle densities is doubtful because denticle densities reflect tooth size, and they referred the specimens to indeterminate Tyrannosauridae. Different ontogenetic stages may also account for denticle density differences with the same species. We also refer these teeth to indeterminate tyrannosauroids.

Lucas et al. (1987) reported on tyrannosaurid teeth UNM FKK-077, FKK-078, and FKK-079 (disposition now unknown), NMMNH P-12999 (= FKK-080), which was referred to *Albertosaurus* sp., and one tooth (NMMNH P-13000 = UNM FKK-076) that was referred to cf. *Tyrannosaurus rex*. These teeth were purportedly from the Naashoibito Member, but Carr and Williamson (2000) concluded that only NMMNH P-13000 was from that unit. They determined that the other teeth were from the stratigraphically lower De-na-zin Member (Kirtland Formation). Because all the specimens, including NMMNH P-13000, are from the same locality, we considered all of them as coming from the De-na-zin Member (Kirtland Formation) rather than from the Naashoibito Member.

Therefore, none of the large carnosaur material from the Naashoibito Member is diagnostic to the genus or the species level. Although some specimens may pertain to *Tyrannosaurus*, more diagnostic material is needed before precise identifications can be determined.

#### Ornithomimisauria Barsbold, 1976

#### Ornithomimidae Marsh, 1890

#### Ornithomimidae indet.

**Referred material:** NMMNH P-22660 (= UNM FKK-019), incomplete ungual phalanx; NMMNH P-37811, incomplete phalanx; NMMNH P-38482, distal portion of metatarsal IV in ~20 pieces.

**Remarks:** These specimens have morphology consistent with members of the Ornithomimidae. Lucas et al. (1987, p. 36) briefly mentioned a "partial claw" (NMMNH P-22660) from the Naashoibito Member that they identified as an indeterminate ornithomimid. NMMNH P-38482 is referable to the Ornithomimidae based on having a distal articulation of metatarsal IV that is ginglymoid and having unguals that are triangular in cross-section with flat ventral surfaces, lacking flexor tubercles, and bearing deep, lateral grooves (Makovicky et al., 2004). Ornithomimids are present in the Naashoibito Member based on this material.



FIGURE 7. Tyrannosauridae indeterminate. A-B, SMP VP- 2105, nearly complete right scapulocoracoid in A, lateral and B, medial views. C-D, SMP VP- 1848, left metatarsal I in C, medial and D, lateral views. Bar scales A-B = 10 cm; C-D = 1 cm.

**Oviraptorosauria Barsbold, 1976****Caenagnathidae Sternberg, 1940*****Ojoraptorsaurus* Sullivan, Jasinski, and Van Tomme, 2011b*****Ojoraptorsaurus boerei* Sullivan, Jasinski, and Van Tomme, 2011b****Fig. 9A-B**

**Holotype:** SMP VP-1458, incomplete pair of fused pubes (Fig. 9A-B).

**Remarks:** *Ojoraptorsaurus boerei* is a new caenagnathid based on the holotype specimen (SMP VP-1458, Fig. 9A-B), a nearly complete pair of fused pubes. The pubes bear an enclosed pubic fossa on the medial surface of the proximal end of the pubic shaft, which serves, with other features, to diagnose this taxon (see Sullivan et al., 2011b). The pubes are distinct from all the other known North American and Asian caenagnathids. *Ojoraptorsaurus boerei* is the first documented occurrence of a caenagnathid from New Mexico.

**Caenagnathidae indeterminate****Fig. 9C-D**

**Referred material:** SMP VP-2172, incomplete pes ungual (Fig. 9C-D).

**Remarks:** A pes ungual, SMP VP-2172 (Fig. 9C-D), is morphologically distinct from those seen in members of the Tyrannosauroidae, Ornithomimosauria and Dromaeosauridae. It is short and robust, with little curvature, and is questionably referred to an indeterminate caenagnathid.

**Troodontidae Gilmore, 1924****Troodontidae indet.****Fig. 9G-H**

**Referred material:** NMMNH P-22566 (= UNM FKK-014), three isolated teeth; SMP VP-3341, nearly complete tooth (Fig. 9G-H).

**Remarks:** Lehman (1981) mentioned that several isolated teeth in the NMMNH collection were referable to Troodontidae (= Saurornithoididae of Lehman, 1981). Lehman (1981, p. 212) stated that “the teeth agree...with those described for *Saurornithoides* junior (Barsbold, 1974)...were it not for the present uncertainties affecting *Saurornithoides*...I would not hesitate to refer the [NMMNH] specimens to that genus.” Consequently he referred the teeth to an indeterminate saurornithoidid. We have not seen these specimens and cannot comment on their taxonomic affinities.

SMP VP-3341 (Fig. 9G-H) is identified as an indeterminate troodontid based on having large, prominent hook-like denticles along the preserved portions of the carinae. The tooth is nearly complete, with 3 denticles present on the anterior edge of the tooth (present towards the tip) and 7 denticles present on the posterior edge (all found towards the base).

**Dromaeosauridae Matthew and Brown, 1922****Dromaeosauridae indet.****Figs. 9E-F, 10**

**Referred material:** SMP VP-2430, manual ungual, tooth, thoracic vertebra, ?rib, ?skull fragments, and other associated fragments and elements (Fig. 10); SMP VP-2505, complete tooth (Fig. 9E-F); SMP VP-2595, complete tooth.

**Remarks:** SMP VP-2430 (Fig. 10) is the remains of an indeterminate dromaeosaurid and represents one of the most completely associated vertebrate specimens recovered from the Naashoibito Member. The specimen is partly encrusted with matrix and is severely crushed, making the identity of individual elements and fragments very difficult. One of the most readily identifiable elements is the manual ungual phalanx (Fig. 10A-B). It measures approximately 4.8 cm long, from the proximal sur-

face to the terminal tip, has a depth of 3.0 cm along the proximal surface, and a depth of 1.5 cm, where it articulates with the penultimate phalanx. An isolated tooth (Fig. 10E-F) is very small, only 1.2 cm in total height, and has approximately 18-20 denticles per 5 mm. There is one relatively well-preserved thoracic vertebra (Fig. 10C-D) that is nearly complete, and several other fragments may represent incomplete vertebrae. There are several longer elements that have not been positively identified. One of these elements is probably an incomplete rib, and another is questionably identified as an incomplete humerus (Fig. 10G-H). There are several isolated fragments that may be parts of the skull, and one may be part of the dentary or mandible. Most of the fragments have yet to be identified. SMP VP-2430 probably represents a new taxon and will be described in detail elsewhere.

SMP VP-2505 (Fig. 9E-F) is a single tooth identified as a relatively large, indeterminate dromaeosaur. The tooth has a total length of 3.4 cm with 12-13 denticles per 5 mm. There are no serrations on the mesial carina of the tooth, although there is a well-developed wear facet, so any original serrations may have been destroyed. SMP VP-2595 is also a dromaeosaur tooth, and while it is smaller than SMP VP-2505, it is more robust and larger than the tooth in SMP VP-2430 (1.4 cm versus 1.2 cm total length), with roughly 16 denticles per 5 mm. The size differences between these two teeth may reflect either specific or ontogenetic differences.

Lehman (1981, text-fig. 9.8) noted a complete metatarsal I from the right pes of a small theropod (in the private collection of Neal Lafon of Albuquerque, New Mexico) that he thought was similar to “*Stenonychosaurus inequalis*” (Russell, 1969), so he identified it as a dromaeosaurid or troodontid. The whereabouts of this specimen are unknown and it cannot be considered further. Lucas et al. (1987) and Hunt and Lucas (1993) indicated the presence of indeterminate dromaeosaurids in the Naashoibito Member, but gave no specimen numbers or specific data for any specimens.

Based on the documented material in the NMMNH and SMP collections, there may be at least two to three indeterminate dromaeosaurid taxa present in the Alamo Wash local fauna. However, the denticle morphology varies within the dentary, maxilla and premaxilla as well as through ontogeny, so isolated teeth cannot be precisely identified.

**Theropoda indet.****Fig. 11**

**Referred material:** NMMNH P-28367, incomplete tooth; NMMNH P-28369, incomplete tooth; SMP VP-1318, incomplete caudal vertebra (Fig. 11A-B); SMP VP-2176, incomplete caudal vertebral centrum; SMP VP-2434, ?skull fragment; SMP VP-2435, questionable skull fragment; SMP VP-2500, two ?parietal fragments and partial braincase; SMP VP-2521, ?skull fragment; SMP VP-2626, incomplete vertebra and associated bone fragments; SMP VP-2069, basal portion of ?premaxillary tooth; SMP VP-2709, incomplete metatarsal; SMP VP-2781, incomplete pedal ungual (Fig. 11C); SMP VP-2788, nearly complete pedal ungual (Fig. 11D-E); SMP VP-3357, pedal phalanx ?III-1 (Fig. 11F-K).

**Remarks:** Several specimens from the Naashoibito Member have been identified as indeterminate theropods. Some material is questionably identified as skull fragments (SMP VP-2434, VP-2435 and VP-2521), and none of the specimens are diagnostic. SMP VP-2500 consists of three bone fragments, two of which have a smooth outer surface that we identify as part of the parietal and a third that has one large foramen and is identified as part of the braincase of a small theropod. SMP VP-2626 is a relatively large, incomplete vertebra from a medium- to large-sized theropod. The two incomplete caudal vertebrae (SMP VP-1318, Fig. 11A-B, and VP-2176) may be of an ornithomimid, dromaeosaur, or some other small- to medium-sized theropod. Examples of theropod unguals (SMP VP-2781, Fig. 11C and SMP VP-2788, Fig. 11D-E) and other phalanges (SMP VP-3357, Fig. 11F-K) document the presence of various small theropods in the AWf.

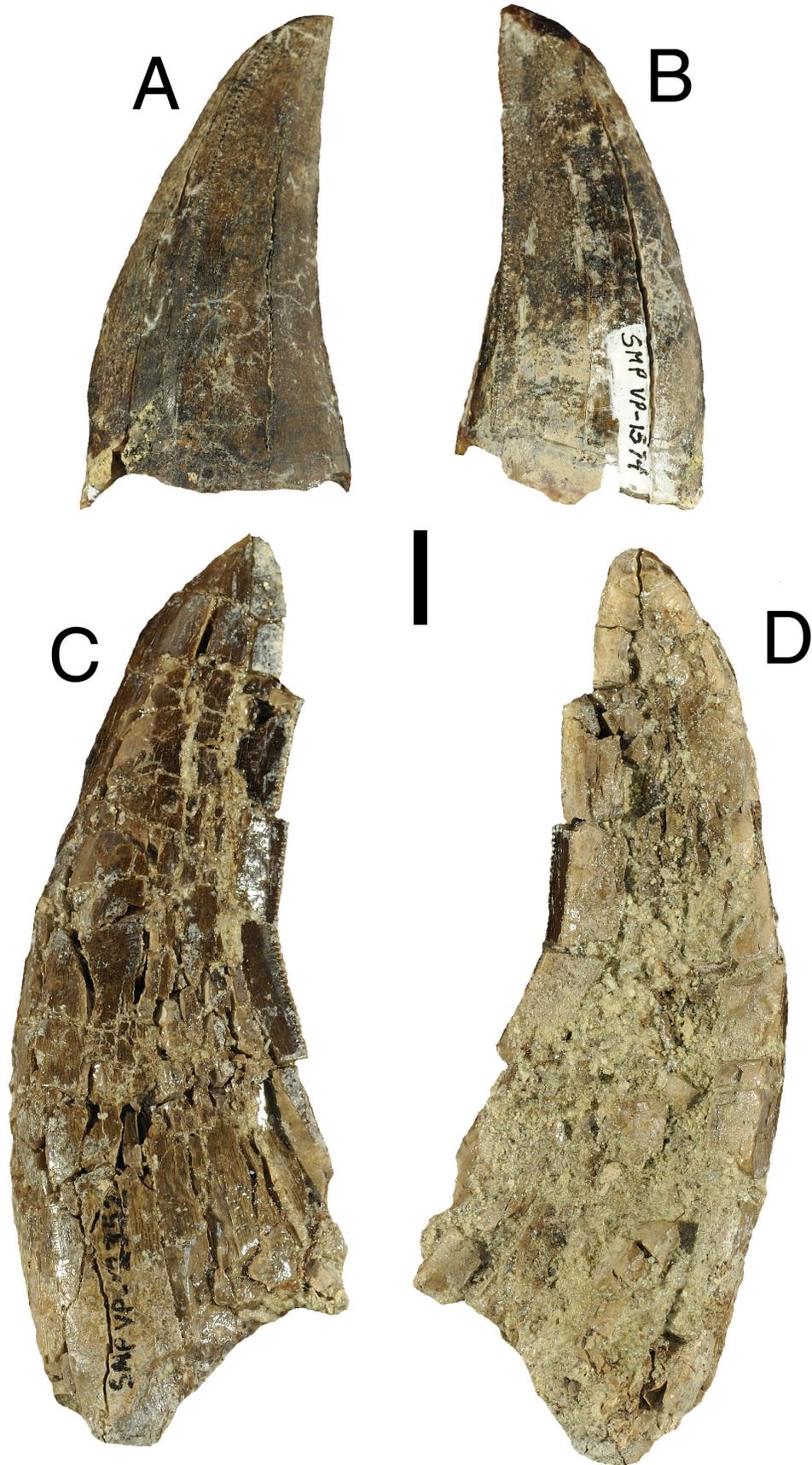


FIGURE 8. Tyrannosauridae indeterminate. A-B, SMP VP-1574, anterior ?dentary tooth in A, labial and B, lingual views. C-D, SMP VP-2352, tooth in C, labial and D, lingual views. Bar scale = 1 cm.

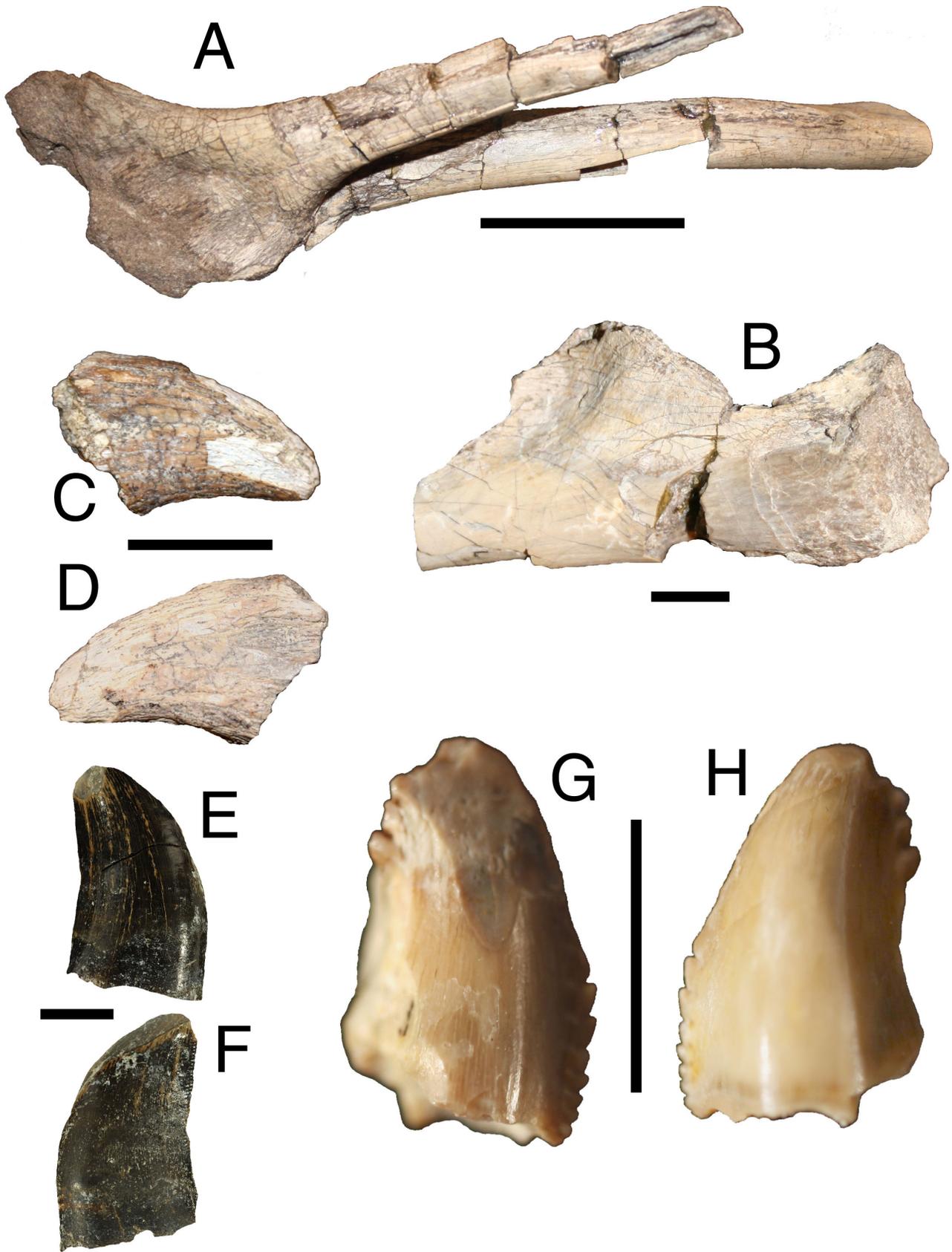


FIGURE 9. Caenagnathidae, Dromaeosauridae and Troodontidae. **A-B**, SMP VP-1458, *Ojoraptorsaurus boerei* (holotype), incomplete pair of fused pubes, **A**, distal portion in oblique left lateral view and **B**, proximal end of left pubes (proximal end to right). **C-D**, SMP VP-2172, ?Caenagnathidae indeterminate, incomplete pes ungual in **C**, right lateral and **D**, left lateral views. **E-F**, SMP VP-2505, Dromaeosauridae indeterminate, tooth in **E**, labial and **F**, lingual views. **G-H**, SMP VP-3341, Troodontidae indeterminate, nearly complete tooth in **G**, lingual and **H**, labial views. Bar scales = 1 cm.

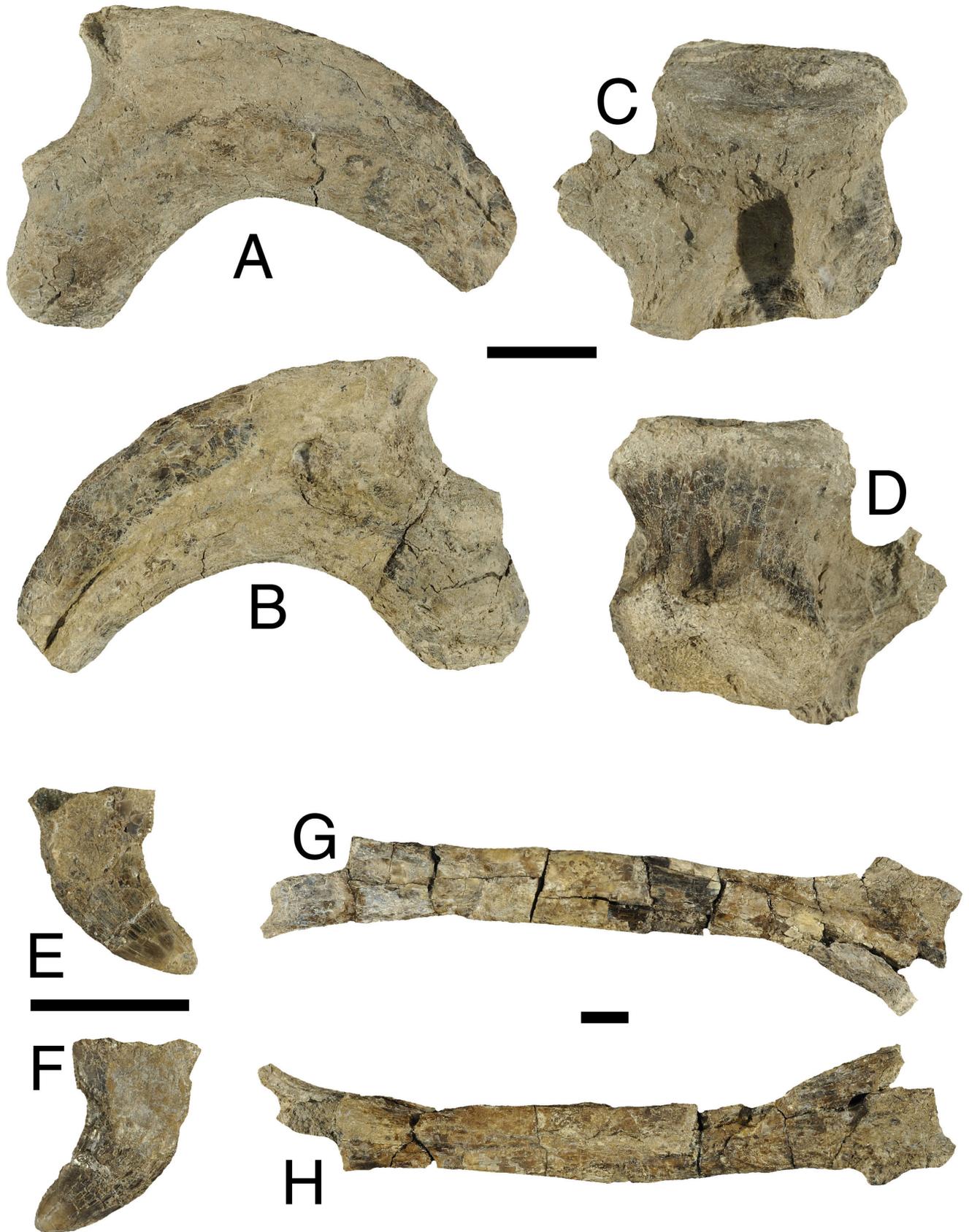


FIGURE 10. Dromaeosauridae indeterminate, SMP VP-2430, incomplete postcranial skeleton and skull: **A-B**, manual ungual in **A**, right lateral and **B**, left lateral views; **C-D**, thoracic (dorsal) vertebra in **C**, dorsal and **D**, ventral views; **E-F**, tooth in **E**, left lateral and **F**, right lateral views; and **G-H**, incomplete right humerus (proximal end to the right) in **G**, cranial and **H**, caudal views. Bar scales = 1 cm.

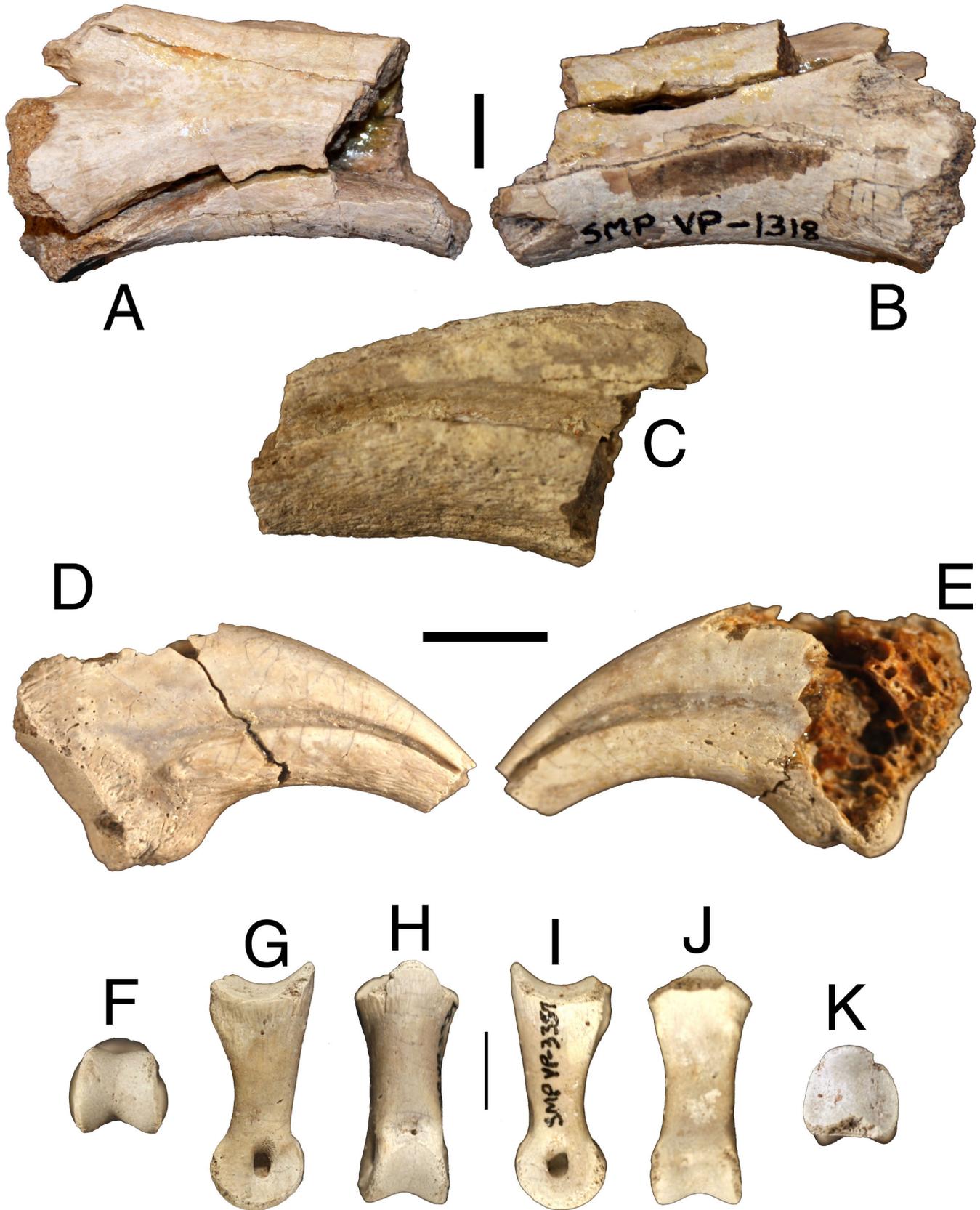


FIGURE 11. Theropoda indeterminate. **A-B**, SMP VP-1318, incomplete caudal vertebra in **A**, left lateral and **B**, right lateral views. **C**, SMP VP-2781, incomplete pedal ungual in left lateral views. **D-E**, SMP VP-2788, nearly complete pedal ungual in **D**, right lateral and **E**, left lateral views. **F-K**, SMP VP-3357, pedal phalanx ?III-1: **F**, distal, **G**, right lateral, **H**, dorsal, **I**, left lateral, **J**, ventral and **K**, proximal views. Bar scales = 1 cm.

SMP VP-2069 is the basal portion of a small ?premaxillary tooth that is D-shape in cross-section, with a slight bulge between the carinae posteriorly. At its base, the tooth measures 7 mm (anteroposteriorly) and has a width of about 5 mm. The carinae are located posterior to the anteriorly-directed curved edge and each bear 15-16 denticles per 5 mm, which is outside the range of most *Tyrannosaurus* teeth (6-9) but closer to the denticle counts of smaller tyrannosaurs like *Albertosaurus* and *Daspletosaurus* (Carr and Williamson, 2000).

Theropods from the Naashoibito Member thus now include tyrannosaurids, dromaeosaurids, caenagnathids, ornithomimids and troodontids.

**Sauropoda Marsh, 1878**

**Titanosauridae Lydekker, 1885**

***Alamosaurus* Gilmore, 1922**

***Alamosaurus sanjuanensis* Gilmore, 1922**

**Figs. 12-20**

**Holotype:** USNM 10486, nearly complete left scapula (Fig. 12A-B).

**Paratype:** USNM 10487, nearly complete right ischium (Fig. 12C-D).

**Referred material:** NMMNH P-22544 (= UNM B-517 and UNM B-518), an incomplete right tibia with distal and proximal ends; NMMNH P-25072 (= UNM B-0709), nearly complete left scapula (Fig. 17); NMMNH P-25077 (= UNM FKK-033), right femur fragment; NMMNH P-27291, anterior caudal vertebra; NMMNH P-28741, incomplete caudal vertebra; NMMNH P-29031, incomplete caudal vertebra; NMMNH P-29722, incomplete #13 or #14 caudal vertebra; NMMNH P-29723, incomplete #3 or #4 caudal vertebra; NMMNH P-29724 (= UNM FK-003), seven tooth fragments; NMMNH P-29725 (= UNM FKK-029), incomplete tooth; NMMNH P-29726, four tooth fragments; NMMNH P-29727 (= UNM FKK-034), nearly complete tooth; NMMNH P-29728 (= UNM B-656), tooth fragment; NMMNH P-49967, partial right crus and pes consisting of the shafts of a tibia and fibula, five metatarsals, two proximal phalanges, and three unguals; PMU.R172, posterior-most sacral vertebra and two anterior-most caudal vertebrae; PMU.R173 (topotype), some poorly-preserved cervical vertebrae; PMU.R174 (topotype), fragment of a right ilium; SMP VP-1138, incomplete left femur; SMP VP-1139, incomplete left pubis; SMP VP-1336, posterior part of the left ilium, with an associated incomplete rib and rib fragments; SMP VP-1494, two incomplete caudal vertebrae; SMP VP-1539, scapula blade; SMP VP-1541, ?skull fragments; SMP VP-1581, distal caudal vertebra (Fig. 19E-G); SMP VP-1582, distal caudal vertebra (Fig. 19C-D); SMP VP-1625, distal end of left femur with associated bone fragments (Fig. 14); SMP VP-1626, nearly complete right fibula (Fig. 15A-B); SMP VP-1641, fragments from dorsal vertebra; SMP VP-1715, a coracoid, part of a ?scapula, neural spine, incomplete ?vertebra, and associated fragments; SMP VP-1718, femur fragment with muscle scar present; SMP VP-1850, posterior cervical vertebra (Fig. 18A-C); SMP VP-1864, incomplete dorsal vertebra; SMP VP-1866, incomplete dorsal vertebra; SMP VP-1876, nearly complete right fibula (Fig. 15C-D); SMP VP-2043, proximal end of tibia; SMP VP-2065, incomplete right fibula with only mid-section present; SMP VP-2097, incomplete left ischium (Fig. 16C) and right femur; SMP VP-2104, incomplete anterior caudal vertebra and bone fragments (Fig. 19A-B); SMP VP-2175, distal end of right radius (Fig. 13E-H); SMP VP-2230, nearly complete caudal vertebra with neural spine (Fig. 20); SMP VP-2232, incomplete thoracic ribs and rib fragments (Fig. 18D); SMP VP-2233, anterior part of right ilium (Fig. 16A-B); SMP VP-2507, nearly complete tooth (Fig. 13A-D); SMP VP-2696, ?chevron and indeterminate bone fragments; SMP VP-3323, incomplete left pubis; and USNM 15658, caudal vertebra (?21st) and caudal neural spine.

**Remarks:** The type specimens of *Alamosaurus sanjuanensis* (USNM 10486, holotype, Fig. 12A-B and USNM 10487, paratype, Fig.

12C-D) were collected from the Naashoibito Member of the Ojo Alamo Formation by J.B. Reeside in 1921 and named by C. W. Gilmore (1922). Later, Gilmore (1946) illustrated a caudal centrum (vertebra) (USNM 15658) from the type area in the San Juan Basin. The type locality is on the south bench of what is now called South Mesa (Bauer, 1916). Mateer (1976) reported on part of a right ilium (PMU.R174), the posteriormost sacral vertebra and the two anteriormost caudal vertebrae (PMU.R172), and some very poorly preserved cervical vertebrae (PMU.R173) and designated them topotypes of *Alamosaurus sanjuanensis*. Lucas and Sullivan (2000a, text-fig. 4) discussed this topotypic material further and illustrated PMU.R173 for the first time. Gilmore (1946) reported on a subsequent specimen, USNM 15658, consisting of a distal caudal centrum (?21st) and a caudal neural spine collected from the type area of *A. sanjuanensis*. Lehman (1981) noted additional material including a crushed right femur (NMMNH P-25077 = UNM FKK-033), incomplete isolated shed teeth (NMMNH P-29724, P-29725 [= UNM FK-029], P-29726, P-29727, P-29728) as well as a distal caudal centrum (UNM B-522) now lost. Most of the teeth were described and illustrated by Kues et al. (1980) and assigned to *Alamosaurus sanjuanensis*. Lehman (1981) reported on an isolated, unusual incomplete scapula (NMMNH P-25072 = UNM B-0709, Fig. 17), which he identified as a hypsilophodontid. The specimen is distinguished, in part, by a prominent dorsally directed process, the anterior part of which is broken, and if complete would have united with the coracoid. The posterior part of the scapular blade is also broken and does not exhibit the squared-off end seen in the holotype (USNM 10486). The maximum length of NMMNH P-25072 is ~57 cm compared to ~155 cm for USNM 10486. Based on the aforementioned features, we interpret NMMNH P-25072 as a juvenile titanosaurid scapula and assign it to *Alamosaurus sanjuanensis*.

Lucas and Sullivan (2000a) and Sullivan and Lucas (2000) reported some specimens of *Alamosaurus* from the underlying De-na-zin Member. The material consisted of an incomplete tooth (SMP VP-1097), a water-worn tooth root (SMP VP-1271), an incomplete left femur (SMP VP-1138), an incomplete left pubis (SMP VP-1139) and three incomplete caudal vertebrae (NMMNH P-28741, P-29722, and P-29723). Since that time, Sullivan and Lucas (2006) discovered that the incomplete tooth (SMP VP-1097) was incorrectly identified and was actually a crocodylian. Lucas and Sullivan (2000a) incorrectly placed SMP VP-1138 and SMP VP-1139 in the De-na-zin Member and subsequent field work has shown that they were both from the Naashoibito Member. SMP VP-1271 was incorrectly identified as a sauropod tooth, and is probably a water-worn incomplete shaft of a small limb bone. Other *Alamosaurus* teeth have been discovered more recently though, including SMP VP-2507 (Fig. 13A-D). The stratigraphic provenance of NMMNH P-28741, P-29722, and P-29723 is probably incorrect due to uncertainty in localities and/or proximity to the De-na-zin/Naashoibito boundary. Williamson and Weil (2008b) discussed the uncertainty of the localities and stratigraphic information of the three caudal vertebrae and felt they were placed incorrectly stratigraphically, and we concur. Williamson and Weil (2008b) found that one specimen (NMMNH P-28741) was recorded as a Fruitland Formation locality, which is also incorrect. They also reinvestigated the locality for NMMNH P-29722 and P-29723 and discovered that they came from the Naashoibito Member (Williamson and Weil, 2008b). Thus, the San Juan Basin *Alamosaurus* occurs only in the Naashoibito Member, Ojo Alamo Formation.

Numerous additional specimens of *Alamosaurus sanjuanensis* have been recovered from the type area and now reside in the collections of the State Museum of Pennsylvania (see list of referred material above). Some of this new material, such as SMP VP-1850 (Fig. 18A-C), a large, incomplete posterior cervical vertebra and a newly acquired specimen from the University of Arizona (NMMNH P-49967, an incomplete right crus and pes), are the subject of forthcoming papers (Fowler and Sullivan, in press; D'Emic, personal communication 2011 to RMS, respectively).

Lastly, there is an incomplete pubis, NMMNH P-26900, that

was collected in the 1970s and identified as a “scapula” of “*Camarasaurus*.” It, however, does not conform to the scapula blade of *Camarasaurus*, rather it compares readily to a left pubis of *Alamosaurus sanjuanensis*, recently collected at the type locality. We therefore identify NMMNH P-26900 as *Alamosaurus sanjuanensis*. Unfortunately, we do not know the locality where the bone came from.

Referral of all this material to *Alamosaurus sanjuanensis* has been a subject of contention among some workers, notably cladists. The Naashoibito Member of the Ojo Alamo Formation is a geographically restricted outcrop in the southwestern portion of the San Juan Basin from Hunter Wash to Betonnie Tsosie Wash (Baltz et al. 1966; Lucas and Sullivan 2000). It is also a relatively thin unit, having a maximum thickness of less than 25.9 m along De-na-zin Wash (Barrel Springs), and a minimum thickness of 1.5 m at Alamo Wash (western branch of Ojo Alamo arroyo) (Baltz et al., 1966); and less than 30 m according to Cather (2004). Because this depositional facies is relatively thin (average maximum thickness of 28 m), it is believed to represent to a very short amount of geologic time. Cather (2004) reported sedimentation rates for the undifferentiated Fruitland/Kirtland formations to be 175 m/m.y. (high) and 145 m/m.y. (low), and for the Ojo Alamo Sandstone (Kimbeto Member), 96 m/m.y. He did not calculate specific rates for the Naashoibito Member. We calculate, based on average sedimentation rates presented by Cather (2004), that the Naashoibito Member (with a 28 m maximum thickness) represents no more than 160,000 to 193,000 years of geologic time, and in reality, probably much less. All the titanosaurid fossils occur as isolated elements within this restricted unit. Therefore, it is logical to assume that all the titanosaurid remains represent a single taxon (i.e., *Alamosaurus sanjuanensis*) based on parsimony. We maintain that the argument that there may be more than one titanosaurid taxon within this restricted unit is not defensible. The onus is on those who claim the multiplicity of titanosaurid taxa to unequivocally demonstrate, with sound and acceptable data, that there is more than a single taxon (*Alamosaurus sanjuanensis*) present in the Naashoibito Member, which is the type stratum for this sauropod dinosaur. Thus, we regard all titanosaurid material from San Juan Basin as *Alamosaurus sanjuanensis*.

#### ORNITHISCHIA

**Thyreophora Nopsca, 1915**

**Ankylosauria Osborn, 1923**

**Ankylosauridae Brown, 1908**

**Ankylosauridae indet.**

**Figs. 21-22**

**Referred material:** NMMNH P-22654, two fragmentary pelvic osteoderms; NMMNH P-33917, complete osteoderm; NMMNH P-46390 (= UNM B-732), isolated tooth; SMP VP-1249, incomplete anterior caudal vertebra; SMP VP-2632, left scapulocoracoid, vertebra with rib attached, vertebra, rib, rib fragments, together with associated and indeterminate bone fragments (Figs. 21-22).

**Remarks:** Ford (2000) originally identified NMMNH P-22654 as *Glyptodontopelta mimus*, but Burns (2008) re-identified it as coming from an indeterminate ankylosaurid. A new specimen, SMP VP-2632 (Figs. 21-22), a nearly complete left scapulocoracoid, two dorsal vertebrae (one with a complete rib in articulation), and rib fragments, is identified as an ankylosaurid similar to, but different from, *Euoplocephalus*, based on the size and shape of the scapulocoracoid (Fig. 22). Additional elements of this specimen are still in the field and will be the target of future collecting. Based on what has been collected so far, the scapulocoracoid does appear distinct from known ankylosaurid (and nodosaurid) scapulocoracoids (M. Burns, pers. communication, 2010). A dorsal vertebra with a rib attached (Fig. 21A) and a separate dorsal vertebra (Fig. 21B-D), are similar to those of both *Ankylosaurus* and *Euoplocephalus* (Sullivan, pers. observation), but not enough is currently known about morphological variation in ankylosaurid vertebrae. Another large anterior caudal vertebra (SMP VP-1249) is identified as an

indeterminate ankylosaurid, based on the presence of a raised notochordal prominence in the center of the centrum, a feature noted in *Ankylosaurus magniventris* (Carpenter, 2004), but also seen in other ankylosaurids.

An isolated tooth (NMMNH P-46390 = UNM B-732) originally referred to ?Pachycephalosauridae by Kues et al. (1977), was subsequently illustrated and identified as an indeterminate nodosaurid (Lucas et al., 1987, fig. 4d-e). We identify it as an indeterminate ankylosaurid tooth based on the prominent central denticle and having a triangular shape.

#### **Nodosauridae Marsh, 1890**

**Glyptodontopelta Ford, 2000**

***Glyptodontopelta mimus* Ford, 2000**

**Figs. 23-26**

**Holotype:** USNM 8610, co-ossified osteoderms (portion of pelvic buckler) (Fig. 23A).

**Paratype:** USNM 8611, co-ossified osteoderms (Fig. 23B-C).

**Referred material:** NMMNH P-14266, 38 osteoderm fragments; NMMNH P-25063 (holotype of *Edmontonia australis*, Ford, 2000, p. 170, fig. 2d), a pair of complete cervical medial osteoderms, one of which is figured here (Fig. 23D); NMMNH P-27405, two fragmentary osteoderms and several osteoderm fragments; NMMNH P-27420, osteoderm; NMMNH P-27450, 11 complete and incomplete osteoderms; NMMNH P-27849, a fragmentary osteoderm and an incomplete pelvic osteoderm; NMMNH P-33917, complete dorsal osteoderm (Fig. 25C-D); SMP VP-1147, complete tertiary cervical/pectoral osteoderm; SMP VP-1319, incomplete osteoderms; SMP VP-1580, anterior end of left dentary, left supraorbital, numerous complete and incomplete osteoderms, and other indeterminate bone fragments (Fig. 24); SMP VP-1622, osteoderm fragments and indeterminate bone fragments; SMP VP-1640, incomplete osteoderms; SMP VP-1821, incomplete osteoderms and indeterminate bone fragments; SMP VP-1825, incomplete shoulder osteoderms; SMP VP-1826, two osteoderm fragments; SMP VP-2026, osteoderm fragments; SMP VP-2067, nearly complete set of fused pelvic osteoderms and unidentified skull elements and fragments (Fig. 25E-F); SMP VP-2077, various incomplete osteoderms; SMP VP-2157, osteoderm fragment; SMP VP-2661, two osteoderm fragments; SMP VP-2786, nearly complete dorsal osteoderm and several incomplete osteoderms and osteoderm fragments (Fig. 25A-B); USNM 8610 (holotype), section of fused pelvic osteoderms (Fig. 23A); USNM 8611, several osteoderm fragments (Fig. 23B-C).

**Remarks:** Ford (2000) named *Glyptodontopelta mimus* based on a set of co-ossified pelvic osteoderms (USNM 8610, holotype; Fig. 23A). The paratype (USNM 8611; Fig. 23B-C) consists of several separate and co-ossified osteoderms. Burns (2008) demonstrated that *Glyptodontopelta* is a valid taxon based on internal (histological) and external osteoderm morphology. More complete material has been found recently, including SMP VP-1580 (Fig. 24), which was assigned to *Glyptodontopelta mimus* by Burns (2008). SMP VP-1580 includes numerous osteoderms of various sizes and shapes, two of which are illustrated here (Fig. 24E-F). The anterior part of the left dentary (Fig. 24A-B) and a left supraorbital (Fig. 24C-D), together with other non-osteoderm bone fragments that are still to be identified, are also part of this specimen. Other specimens of *Glyptodontopelta* consist solely of osteoderms, and include NMMNH P-33917 (Fig. 25C-D), SMP VP-2067 (Fig. 25E-F) and SMP VP-2077 (Fig. 26), among others (see list of referred material, above). Burns (2008) synonymized *Edmontonia australis* Ford, 2000, with *Glyptodontopelta* based on osteoderm morphology, so the Naashoibito specimen designated *E. australis* (NMMNH P-25063) is now *G. mimus* (Fig. 23D). Burns (2008) also assigned NMMNH P-27420 and P-27450 to *Glyptodontopelta* based on external osteoderm morphology. We recognize *Glyptodontopelta mimus* as a taxon characteristic of the AWf.

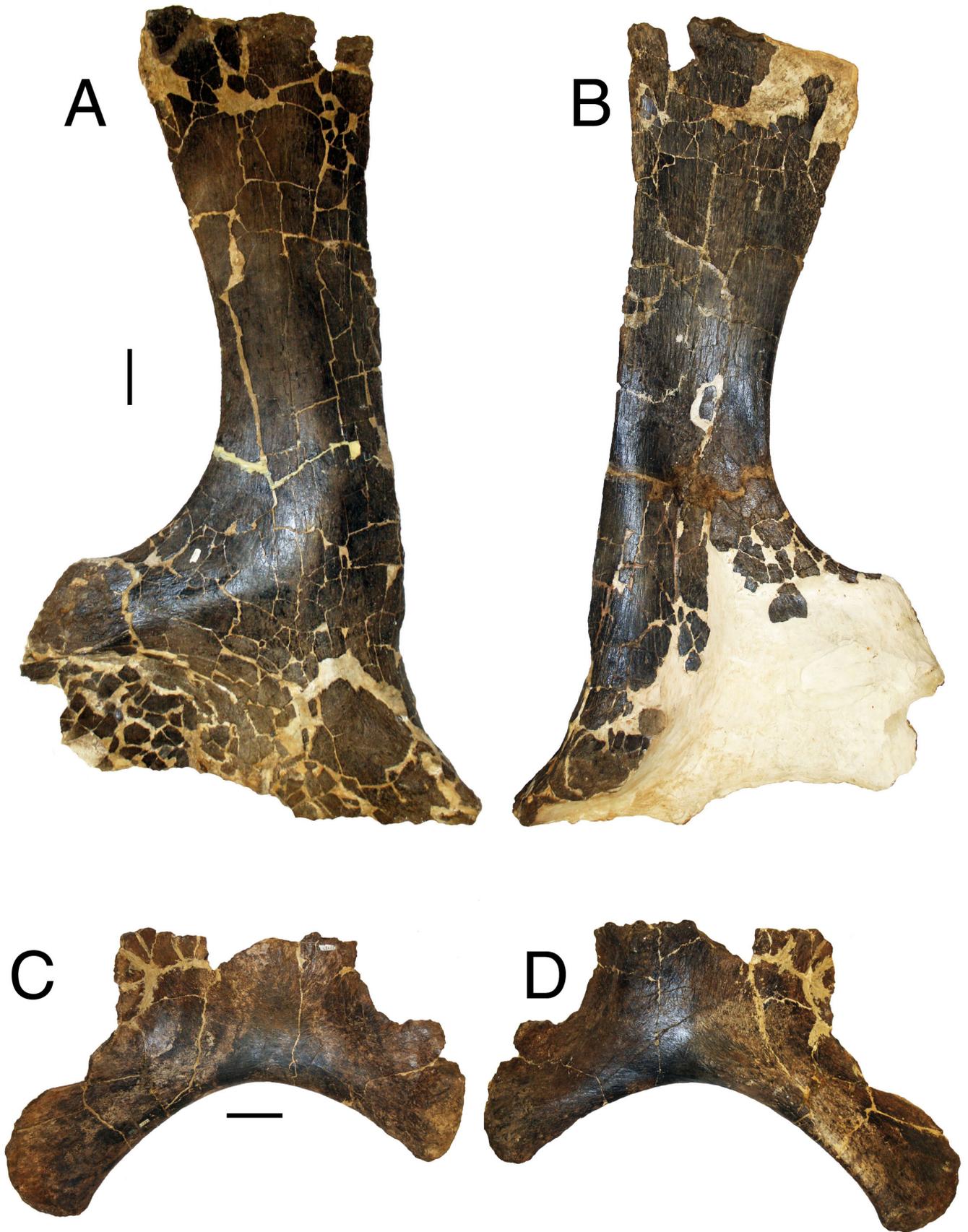


FIGURE 12. *Alamosaurus sanjuanensis*. **A-B**, USNM 10486 (holotype), nearly complete left scapula in **A**, left lateral (dorsal to left) and **B**, medial (dorsal to right) views. **C-D**, USNM 10487 (paratype), nearly complete right ischium in **C**, internal and **D**, external views. Bar scales = 10 cm.



FIGURE 13. *Alamosaurus sanjuanensis*. A-D, SMP VP-2507, nearly complete isolated tooth in A, labial, B, anterior, C, posterior and D, lingual views. E-H, SMP VP-2175, distal end of right radius in E, medial, F, posterior, G, lateral and H, anterior views. Bar scales A-D = 1 cm; E-H = 10 cm.

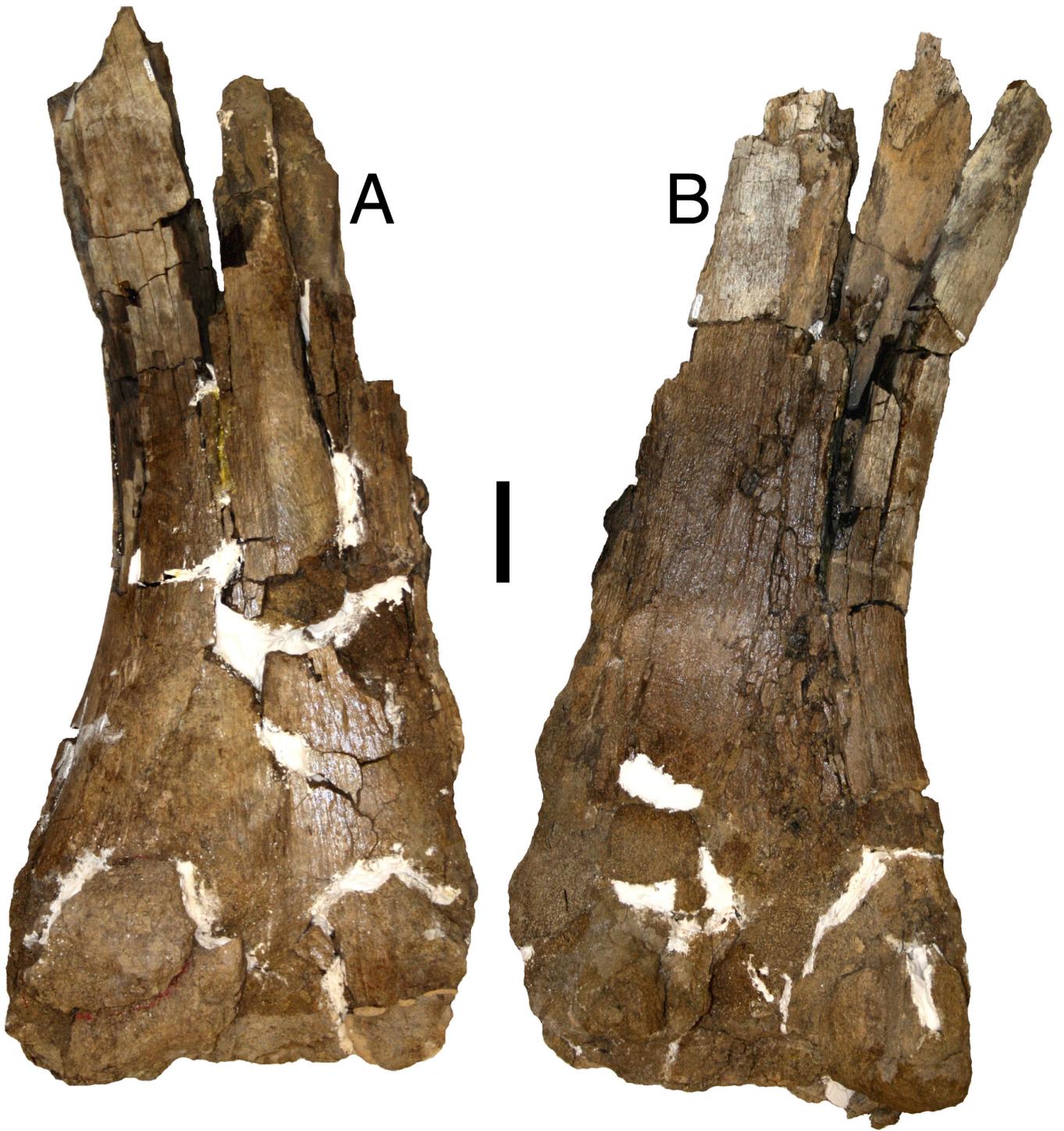


FIGURE 14. *Alamosaurus sanjuanensis*. SMP VP-1625, distal end of left femur in **A**, anterior and **B**, posterior views. Bar scale = 10 cm.



FIGURE 15. *Alamosaurus sanjuanensis*. A-B, SMP VP-1626, nearly complete right fibula in A, lateral and B, medial views. C-D, SMP VP-1876, nearly complete right fibula in C, lateral and D, medial views. Proximal end is to the right for both specimens. Bar scale = 10 cm.

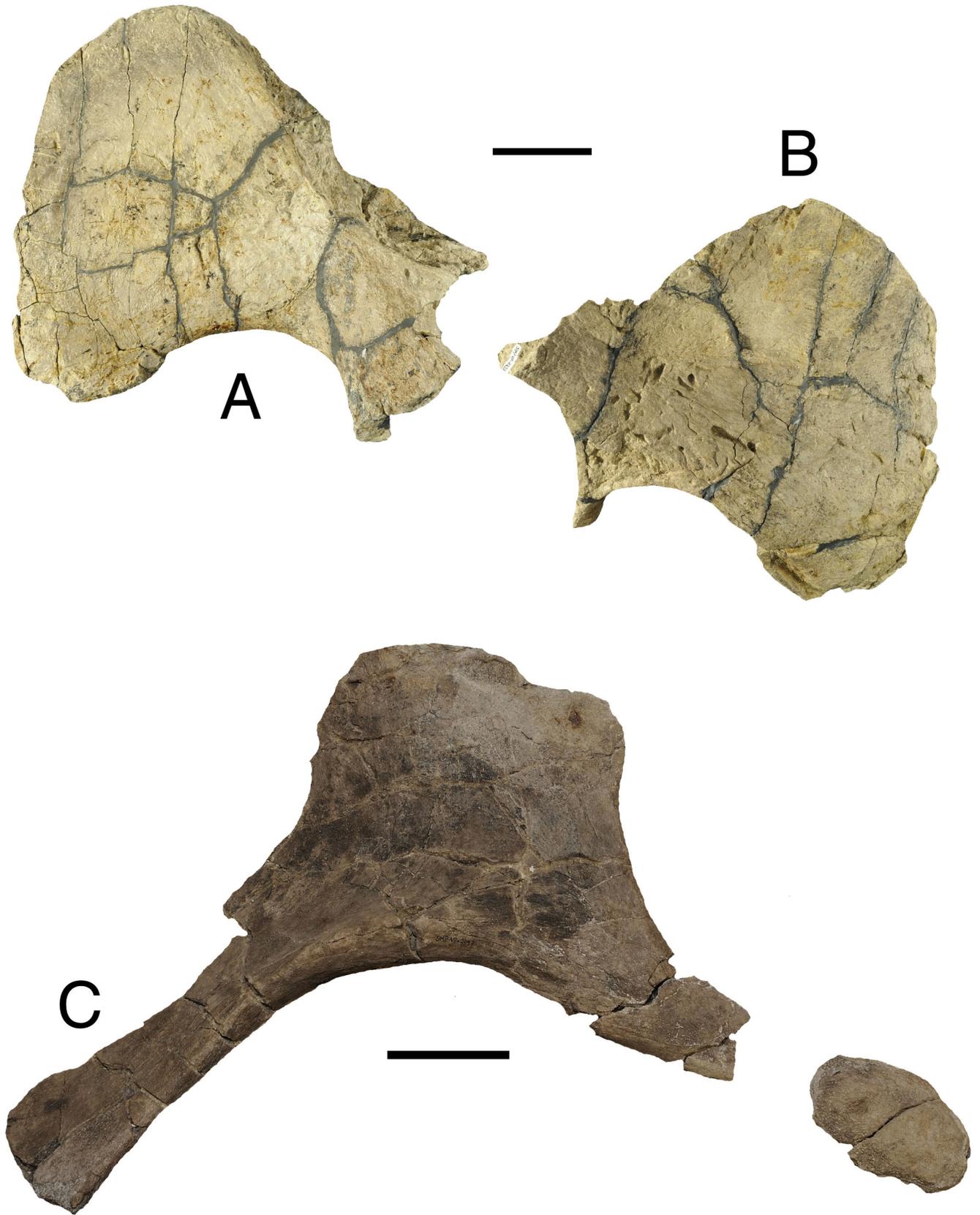


FIGURE 16. *Alamosaurus sanjuanensis*. A-B, SMP VP-2233, anterior part of right ilium in A, lateral and B, medial views. C, SMP VP- 2097, incomplete left ischium in lateral view. Bar scales = 10 cm.



FIGURE 17. *Alamosaurus sanjuanensis*. NMMNH P-25072, nearly complete left scapula (juvenile/subadult) in A, lateral, B, medial and C, dorsal views. Bar scale = 10 cm.



FIGURE 18. *Alamosaurus sanjuanensis*. A-C, SMP VP-1850, posterior cervical vertebra in A, posterior axial, B, right lateral and C, dorsal (posterior end is bottom) views. D, SMP VP-2232, incomplete right thoracic rib in posterior view. Bar scales = 10 cm.

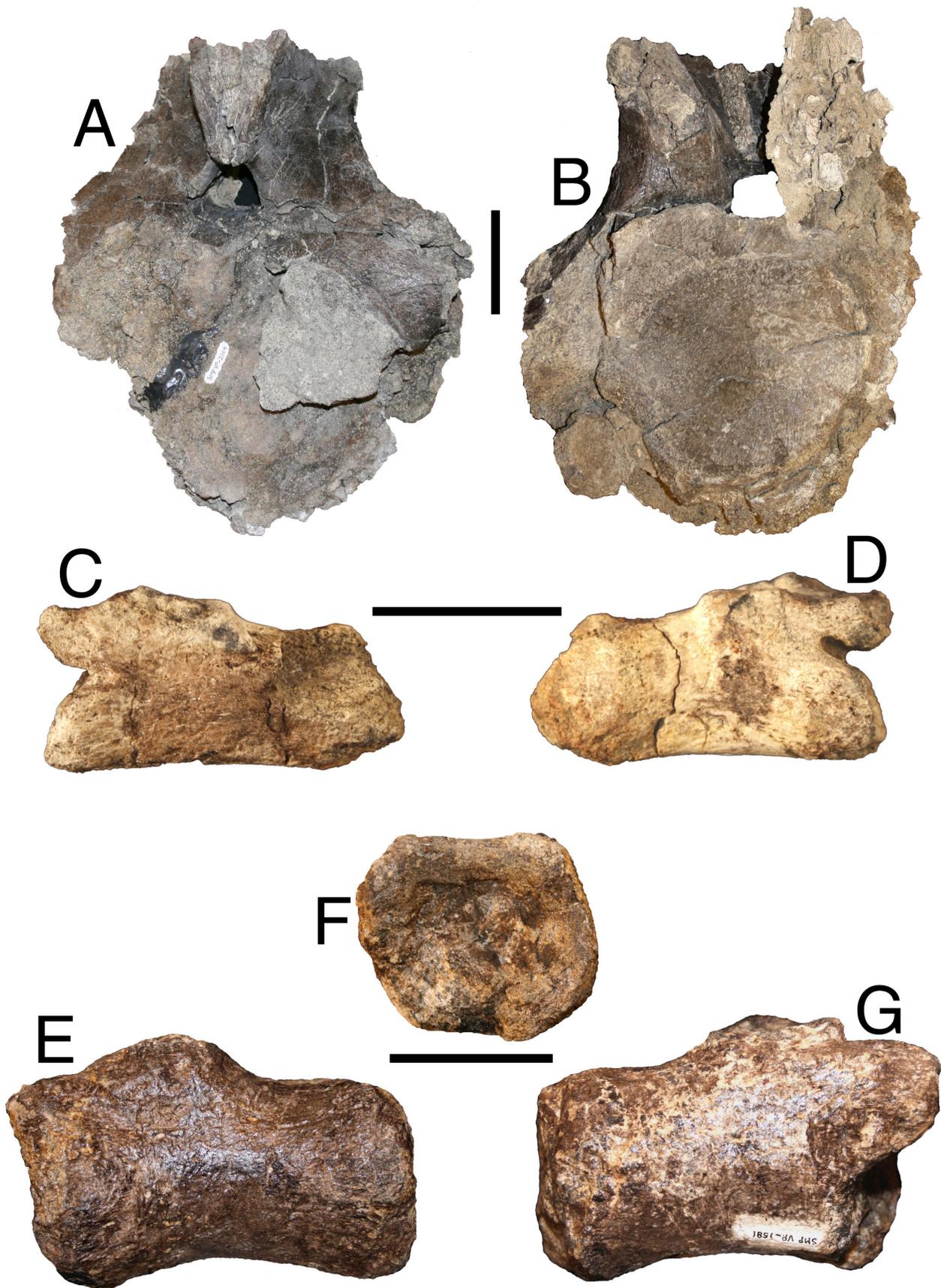


FIGURE 19. *Alamosaurus sanjuanensis*. A-B, SMP VP-2104, incomplete anterior caudal vertebra (possible second or third) in A, posterior and B, anterior views. C-D, SMP VP-1582, distal caudal vertebra in C, left lateral and D, right lateral views. E-G, SMP VP-1581, distal caudal vertebra in E, left lateral, F, posterior axial and G, right lateral views. Bar scales A-B = 10 cm; C-G = 5 cm.

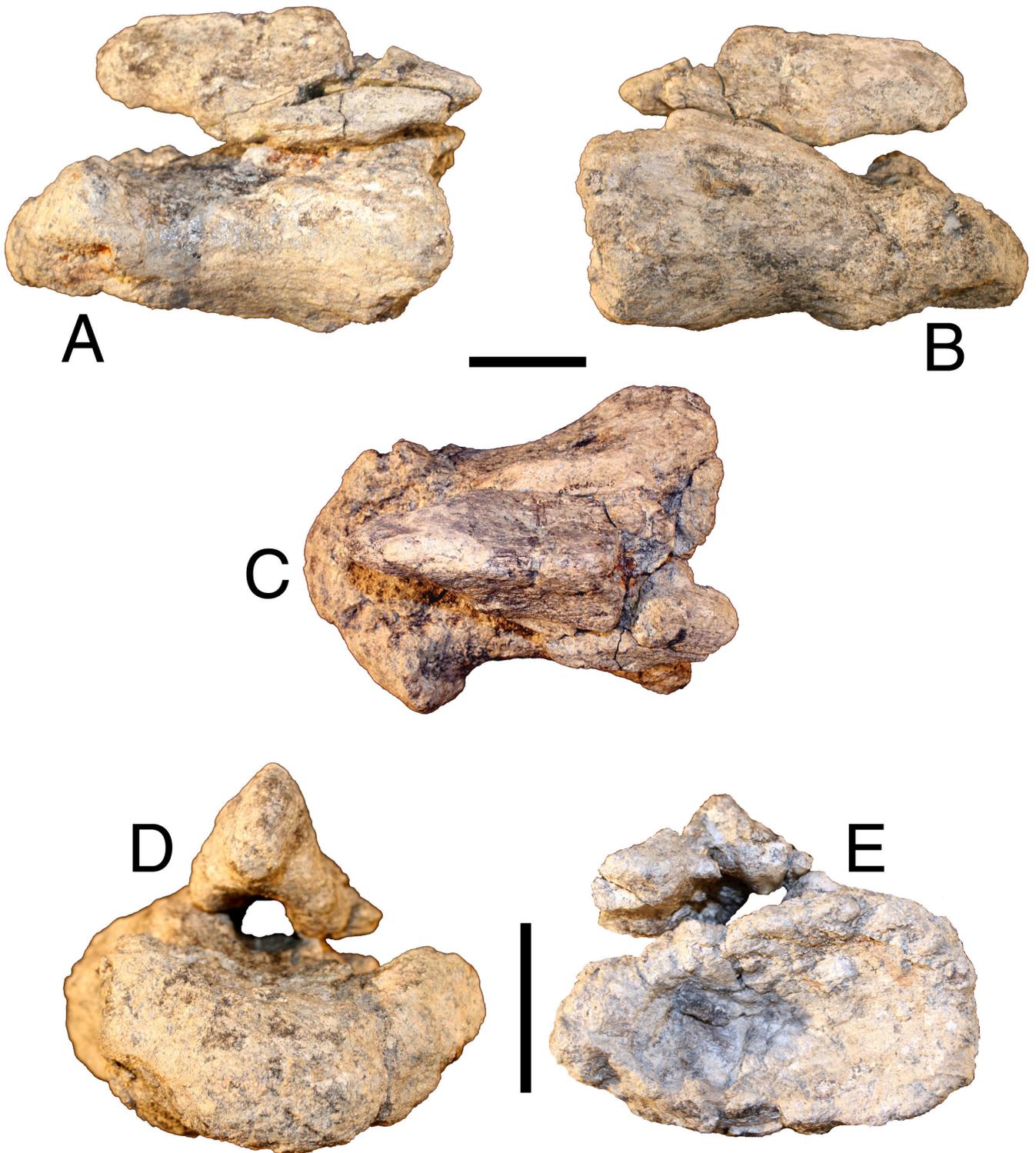


FIGURE 20. *Alamosaurus sanjuanensis*. SMP VP-2230, nearly complete caudal vertebra in A, right lateral, B, left lateral, C, dorsal, D, posterior axial and E, anterior axial view. Bar scale = 5 cm.

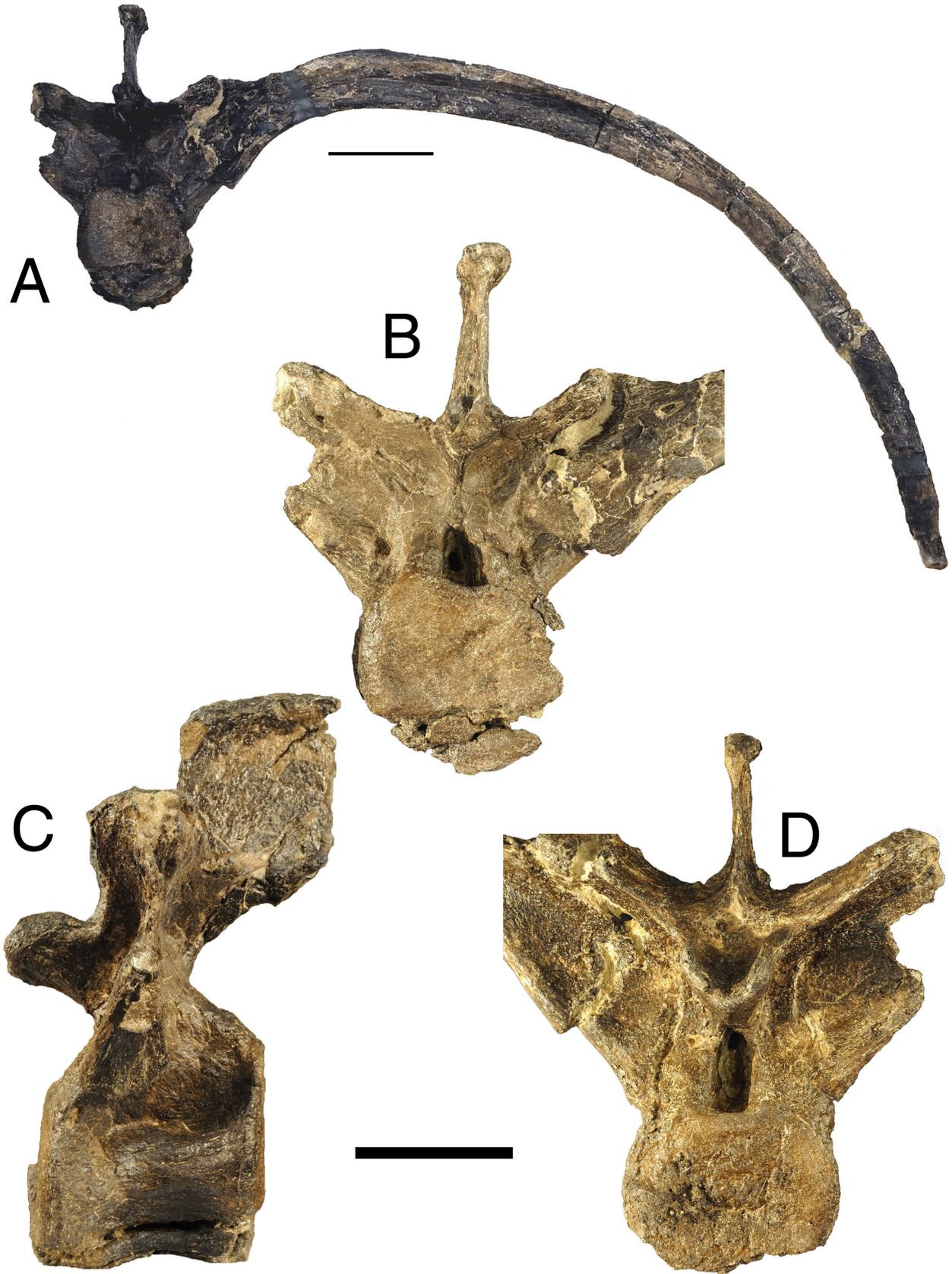


FIGURE 21. Ankylosauridae indeterminate. SMP VP-2632, vertebra with rib in **A**, anterior axial view; close-up of vertebra in **B**, anterior axial, **C**, left lateral and **D**, posterior axial views. Bar scales **A** = 10 cm; **B-D** = 5 cm.



**A**

**B**

FIGURE 22. Ankylosauridae indeterminate. SMP VP-2632, left scapulocoracoid in **A**, left lateral and **B**, medial views. Bar scale = 10 cm.



FIGURE 23. *Glyptodontopelta mimus*. **A**, USNM 8610 (holotype) fused pelvic osteoderms in dorsal view. **B-C**, USNM 8611 (paratype), osteoderms, **B**, close-up of one fragment and **C**, fused fragmentary osteoderms. **D**, NMMNH P-25063 (holotype of *Edmontonia australis*), cervical medial osteoderm in dorsal view. Bar scales **A-C** = 10 cm; **D** = 5 cm.

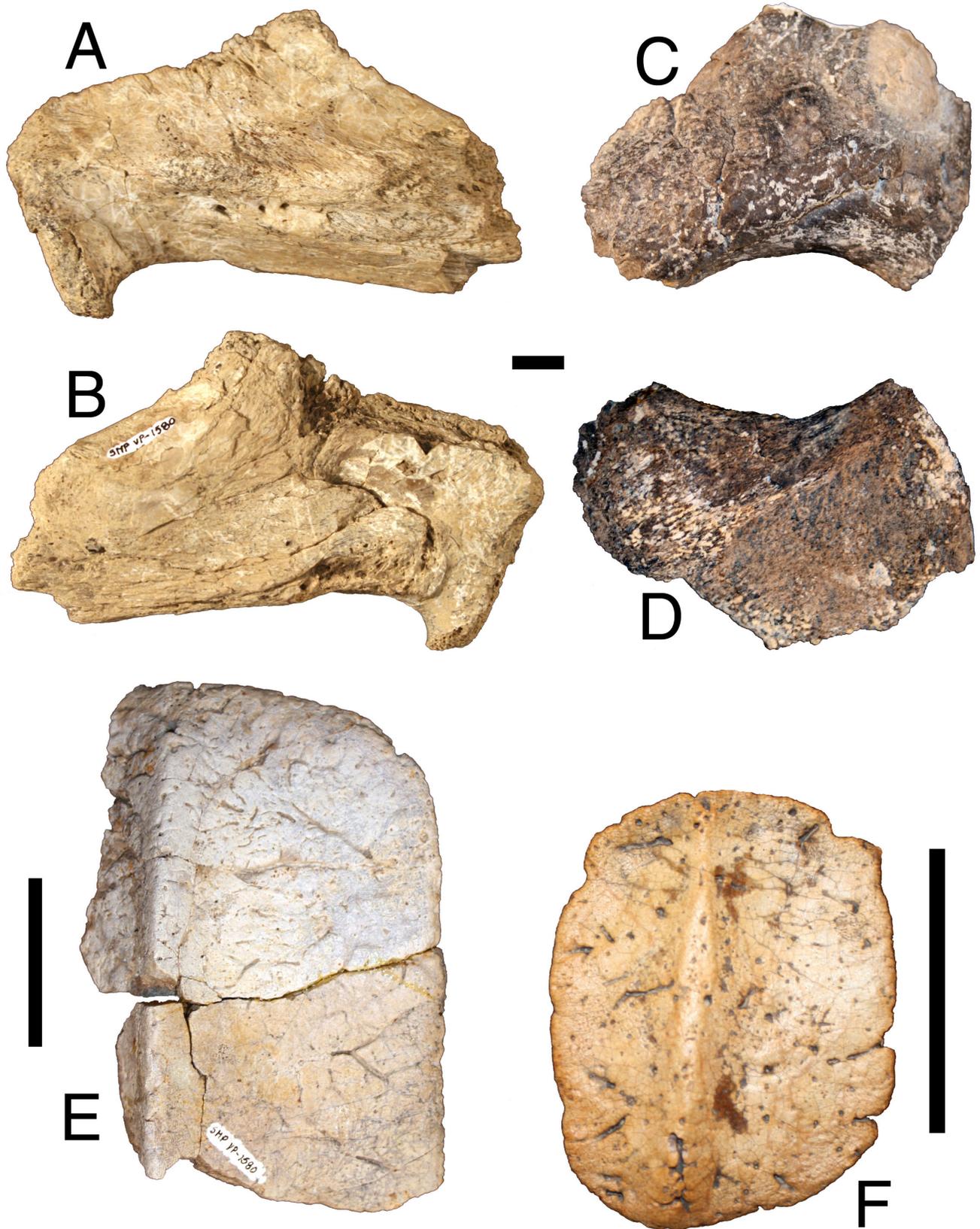


FIGURE 24. *Glyptodontopelta mimus*. SMP VP-1580 (in part), **A-B**, Anterior end of left dentary in **A**, labial and **B**, lingual views; **C-D**, left supraorbital in **C**, dorsal and **D**, ventral views; **E**, incomplete left medial cervical/pectoral osteoderm in dorsal view and **F**, left dorsal thoracic osteoderm in dorsal view. Bar scales **A-D** = 1 cm; **E-F** = 5 cm.

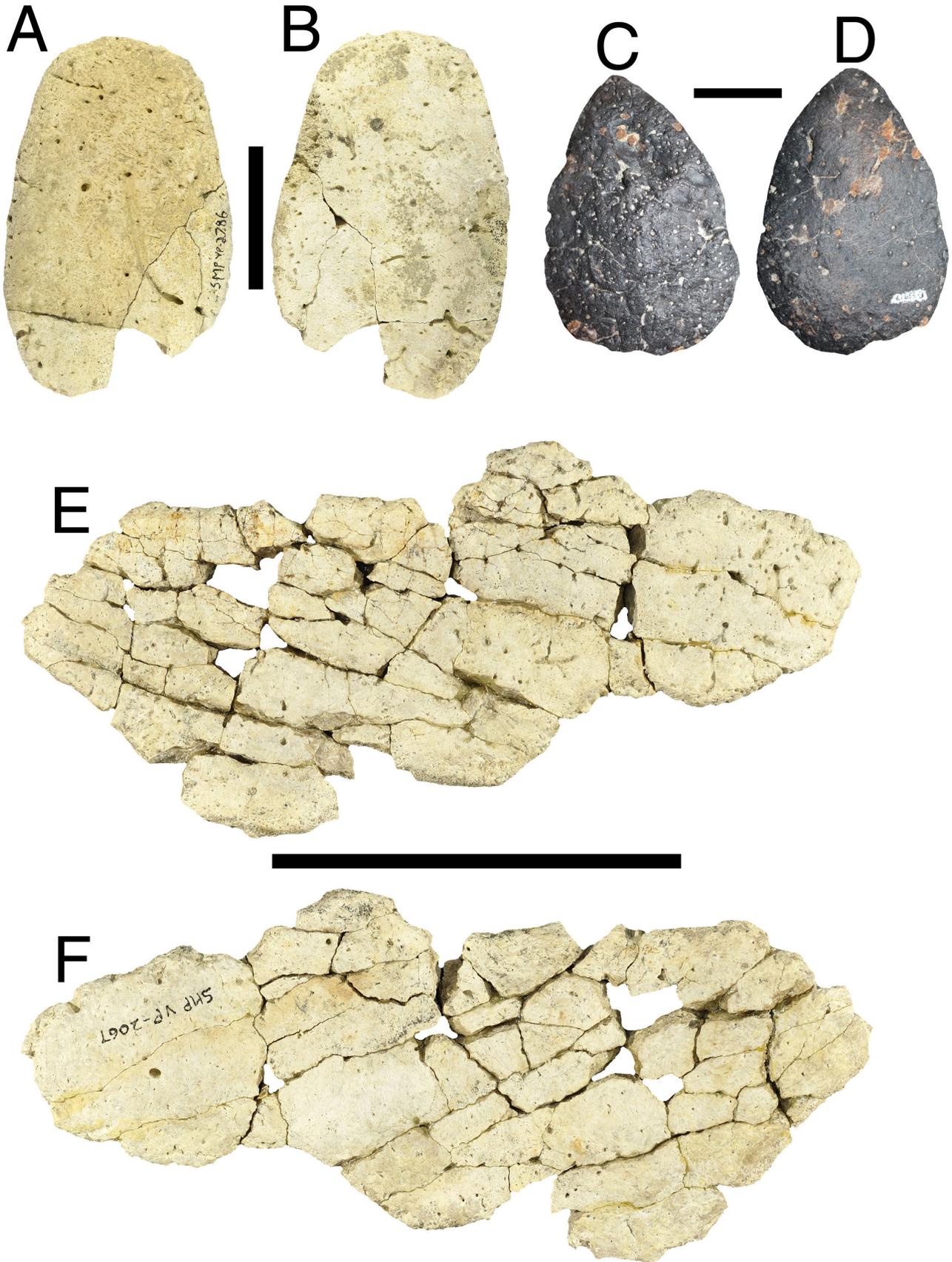


FIGURE 25. *Glyptodontopelta mimus*. A-B, SMP VP-2786, dorsal osteoderm in A, dorsal and B, ventral views. C-D, NMMNH P-33917, dorsal osteoderm in C, dorsal and D, ventral views. E-F, SMP VP-2067, coossified pelvic osteoderms in E, dorsal and F, ventral views. Bar scales A-D = 5 cm; E-F = 10 cm.

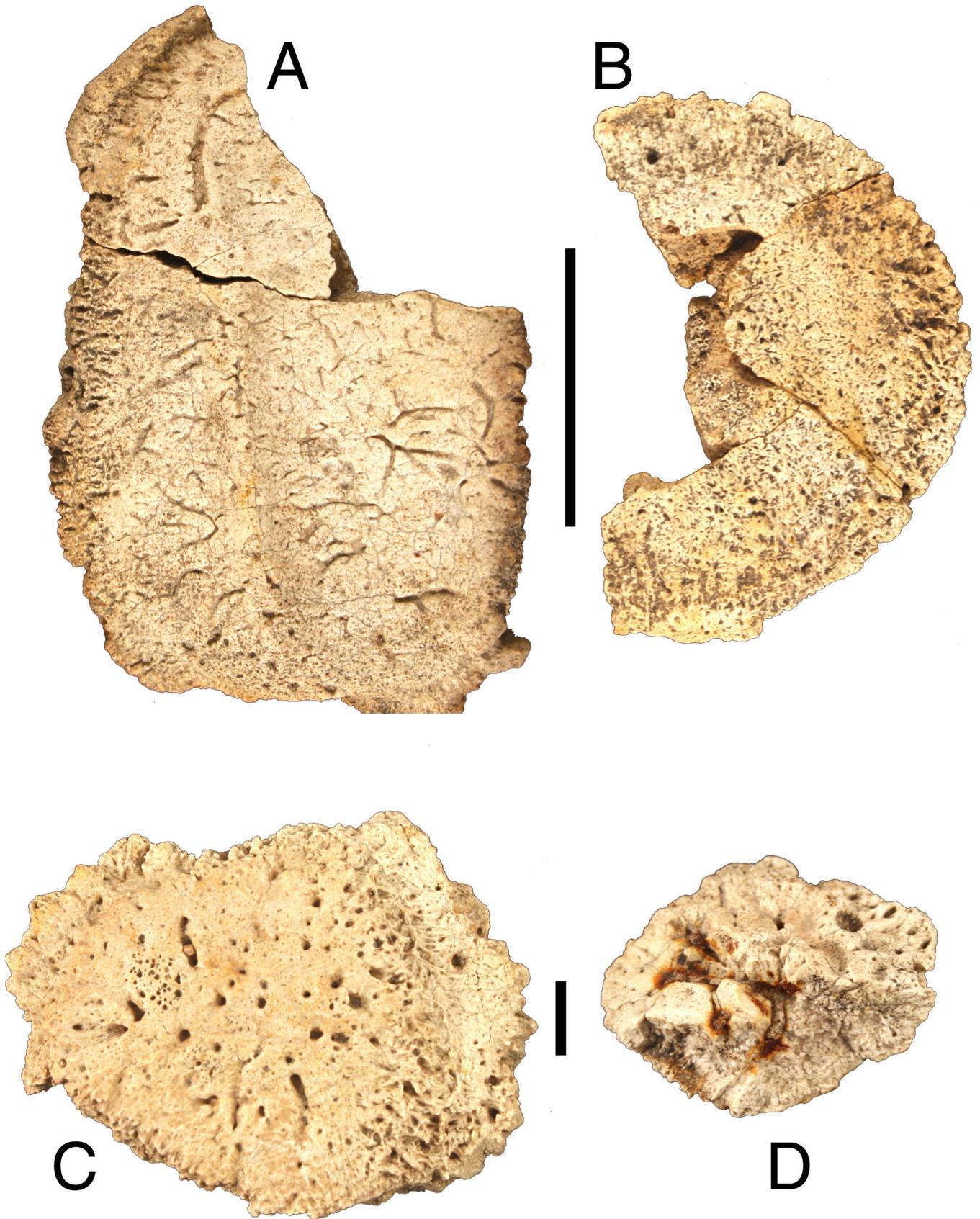


FIGURE 26. *Glyptodontopelta mimus*. SMP VP-2077, various osteoderms, **A**, incomplete cervical osteoderm in dorsal view; **B**, incomplete dorsal circular osteoderm in dorsal view; **C**, dorsal osteoderm in dorsal view; **D**, incomplete small dorsal osteoderm in dorsal view. Bar scales **A-B** = 5 cm; **C-D** = 1 cm.

### Ankylosauria indet.

**Referred material:** SMP VP-1570, incomplete osteoderm; SMP VP-1573, osteoderm; SMP VP-1731, nearly complete osteoderm; SMP VP-1831, osteoderm; SMP VP-1832, incomplete osteoderm; SMP VP-1863, osteoderm; SMP VP-2048, incomplete osteoderm and two indeterminate bone fragments; SMP VP-2355, three osteoderm fragments; SMP VP-2519, two osteoderm fragments; USNM 8571, nearly complete left scapula.

**Remarks:** Indeterminate ankylosaur material from the Naashoibito Member consists mostly of osteoderms. Some of these osteoderms may pertain to *Glyptodontopelta minus*, but because the texture does not appear to be the same we are hesitant to refer them to that nodosaurid. Other osteoderms may pertain to an ankylosaurid, but because of the uncertainty in their generic identification we also include them here.

Gilmore (1919) first reported on a nearly complete left scapula (USNM 8571) from “10 to 12 feet above the base of the Ojo Alamo Sandstone” [= Formation], referring it to the Scelidosauridae. Later, Lehman (1981, p. 211) referred USNM 8571 to the Nodosauridae (*sensu* Coombs, 1978) and tentatively to the taxon *?Panoplosaurus* sp. because it was “indistinguishable from the scapula associated with *Panoplosaurus* (= *Edmontonia rugosidens* (Russell, 1940).” The scapula is not referable to *Panoplosaurus*, although it probably is nodosaurid and may pertain to *Glyptodontopelta*. Presently, we consider it as an indeterminate ankylosaur.

Lucas et al. (1987) reported on a nearly complete left humerus (UNM FKK-084) identified as that of a juvenile indeterminate ankylosaurid. The specimen appears not to be an ankylosaur humerus and was identified as an indeterminate hadrosaurid metatarsal 4 and reported as lost by Williamson (2000). The specimen was probably not from the Naashoibito Member, but rather from the underlying De-na-zin Member (Kirtland Formation), and is not considered further.

### Ornithopoda Marsh, 1881

#### Lambeosaurinae Parks, 1923

##### Lambeosaurinae indet.

#### Lambeosaurini Sullivan, Jasinski, Guenther and Lucas, 2011a

##### Lambeosaurini indet.

##### Figs. 27-28

**Referred material:** NMMNH P-19147, 22 ribs or partial ribs, two dorsal vertebrae, five neural spines, an ossified tendon, a poorly preserved sacrum, an incomplete right scapula, portions of both pubes, and distal end of a tibia (Fig. 28); SMP VP-1534, nearly complete right jugal (Fig. 27C-D); SMP VP-2263, nearly complete left humerus (Fig. 27A-B).

**Remarks:** Sullivan et al. (2011a) documented SMP VP-1534 (Fig. 27C-D) and VP-2263 (Fig. 27A-B) as a lambeosaurin closely related to *Corythosaurus*. NMMNH P-19147 (Fig. 28) represents the most complete, articulated dinosaur skeleton yet recovered from the Naashoibito Member. Hunt and Lucas (1991) identified NMMNH P-19147 as a *Corythosaurus*-like lambeosaurine based mostly on morphology of the pubis (Fig. 28A-B), which is relatively short and broad, similar to that of most lambeosaurines, especially *Corythosaurus* (Brett-Surman, 1989, pl. 5B; Hunt and Lucas, 1991, fig. 2b; Weishampel et al., 2004, fig. 20.12b). The scapula in *Corythosaurus* is said to be highly variable, and not very useful in identification (Hunt and Lucas, 1991). Williamson (2000, p. 205) thought that NMMNH P-19147 was referable to a hadrosaurine because “the neck of the pubis is narrow rather than broad... and the scapula is relatively long with sub-parallel anterior and posterior margins” (Fig. 28C-D). However, Hunt and Lucas (1991) were correct with their referral; there are distinct similarities between the specimen and *Corythosaurus*, which are also discussed by Sullivan et al. (2011a).

The Naashoibito lambeosaurin fossils represent one of the youngest occurrences of lambeosaurines in North America. *Hypacrosaurus*

*altispinus* occurs in the early Maastrichtian of the Horseshoe Canyon Formation of Alberta, so the Naashoibito specimens represent only the second known North American lambeosaurine from the Maastrichtian.

Lehman (1981) thought the exclusion of *Parasaurolophus* from the Alamo Wash local fauna was an oversight because of an unpublished note from Sternberg to Wiman, although it turns out that Sternberg simply had the stratigraphic horizon where he collected the holotype of *P. tubicen* incorrect. None of the indeterminate lambeosaurin material from the Naashoibito listed above conforms to *Parasaurolophus*, which is quite distinct from other lambeosaurines. C.H. Sternberg collected a fragmentary hadrosaur skull in 1921 that he indicated was from the Naashoibito Member (Wiman, 1931). However, R.M. Sullivan and others collected another, more complete specimen of *P. tubicen* from the De-na-zin Member of the Kirtland Formation in 1995 (Sullivan and Williamson, 1999). This specimen shows that *P. tubicen* was actually from older strata than the Naashoibito Member. Therefore, *Parasaurolophus* is not considered part of the AWlf.

### Hadrosauridae indet.

**Referred material:** NMMNH P-22544, incomplete right tibia; SMP VP-1247, weathered and incomplete caudal vertebra; SMP VP-1320, incomplete tendon; SMP VP-1624, vertebrae and associated fragments; SMP VP-1867, incomplete rib and vertebra fragments; SMP VP-2050, nearly complete fibula SMP VP-2087, skull fragments with incomplete coronoid process; SMP VP-2508, 28 teeth and tooth fragments; SMP VP-2692, 18 teeth; SMP VP-2809, ?ossified tendons; SMP VP-2823, nearly complete caudal centrum (Fig. 27E-F).

**Remarks:** Numerous fossils of indeterminate hadrosaurids have been collected from the Naashoibito Member. Further collection and study is needed to see if more than one hadrosaurid taxon is present in the Naashoibito Member. Lehman (1981, p. 203-207, text-fig. 9.10) reported on several hadrosaurid specimens from the Naashoibito Member in the NMMNH collection, including an incomplete right tibia with the distal and proximal ends preserved (NMMNH P-22544 = UNM B-517/B-518), as evidence of a very large hadrosaurid in the Naashoibito Member (Lehman, 1981, text-fig. 9.10B). This has since been identified in the NMMNH collection as an incomplete tibia of *Alamosaurus* (see above). While most hadrosaurid material from the Naashoibito Member is very fragmentary and offers few diagnostic features, more complete specimens, such as SMP VP 2823 (Fig. 27E-F), are being found and increase the knowledge of the hadrosaurs present.

The holotype of *Kritosaurus navajovius* (AMNH 5799) was collected by Barnum Brown in 1904 near Ojo Alamo, but no precise stratigraphic information was given (Brown, 1910). C.W. Gilmore later learned from Brown that the holotype specimen came from the upper shale member (= De-na-zin Member) of the Kirtland Formation (Gilmore, 1916). Sinclair and Granger (1914) later collected a maxillary and part of a lower jaw (AMNH 5797) from “a few feet above the conglomerate separating the two horizons at which dinosaur bones were found.” *Kritosaurus* has not since been found in the Naashoibito, and the only hadrosaur material diagnostic below the family level is that of an indeterminate *Corythosaurus*-like lambeosaurine (see above). *Kritosaurus* is, therefore, removed from the Alamo Wash local fauna until diagnostic material can be found or identified in the Naashoibito Member. *Naashoibitosaurus ostromi* was originally thought to come from the Naashoibito Member, but has since been found to come from the underlying De-na-zin Member, and is considered by some to be synonymous with *Kritosaurus* (Williamson, 2000). Lehman (1981) and Williamson (2000) reported on a large, incomplete left humerus (NMMNH P-25082 = UNM B-706), initially identified by Lehman (1981) as a large hadrosaurine from the Naashoibito Member (Lehman, 1981; Williamson, 2000). As with the holotype of *Kritosaurus navajovius*, this specimen has been reassessed as coming from the Kirtland Formation, not the Naashoibito Member, and thus is not considered further. Presently, there are no specimens that can be identified as hadrosaurine from the

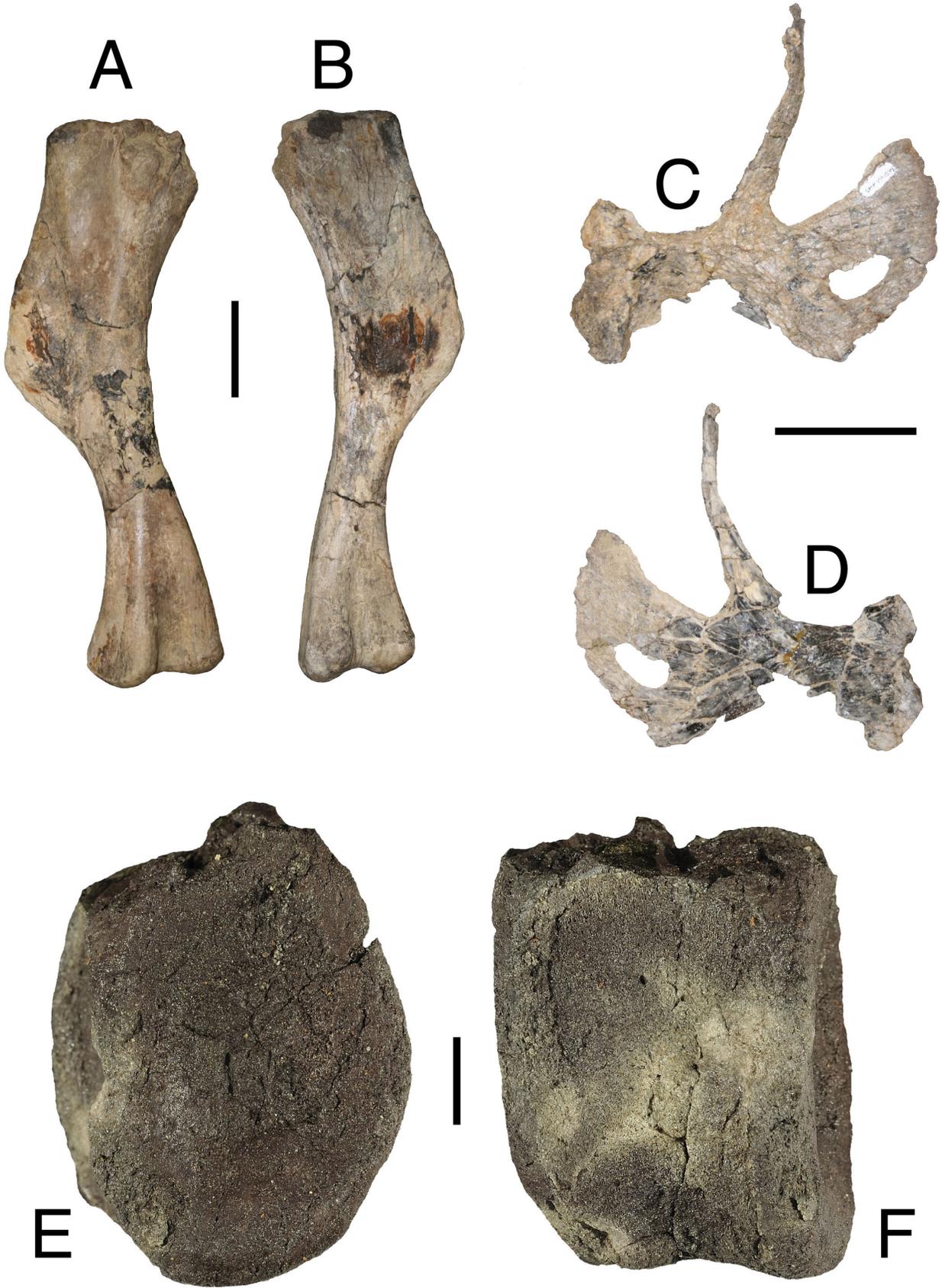


FIGURE 27. Hadrosauridae. **A-B**, SMP VP-2263, Lambeosaurini indeterminate, nearly complete left humerus in **A**, caudal and **B**, cranial views. **C-D**, SMP VP-1534, Lambeosaurini indeterminate, weathered right jugal in **C**, medial and **D**, lateral views. **E-F**, SMP VP-2823, nearly complete caudal centrum in **E**, anterior axial and **F**, right lateral views. Bar scales **A-D** = 10 cm; **E-F** = 1 cm.

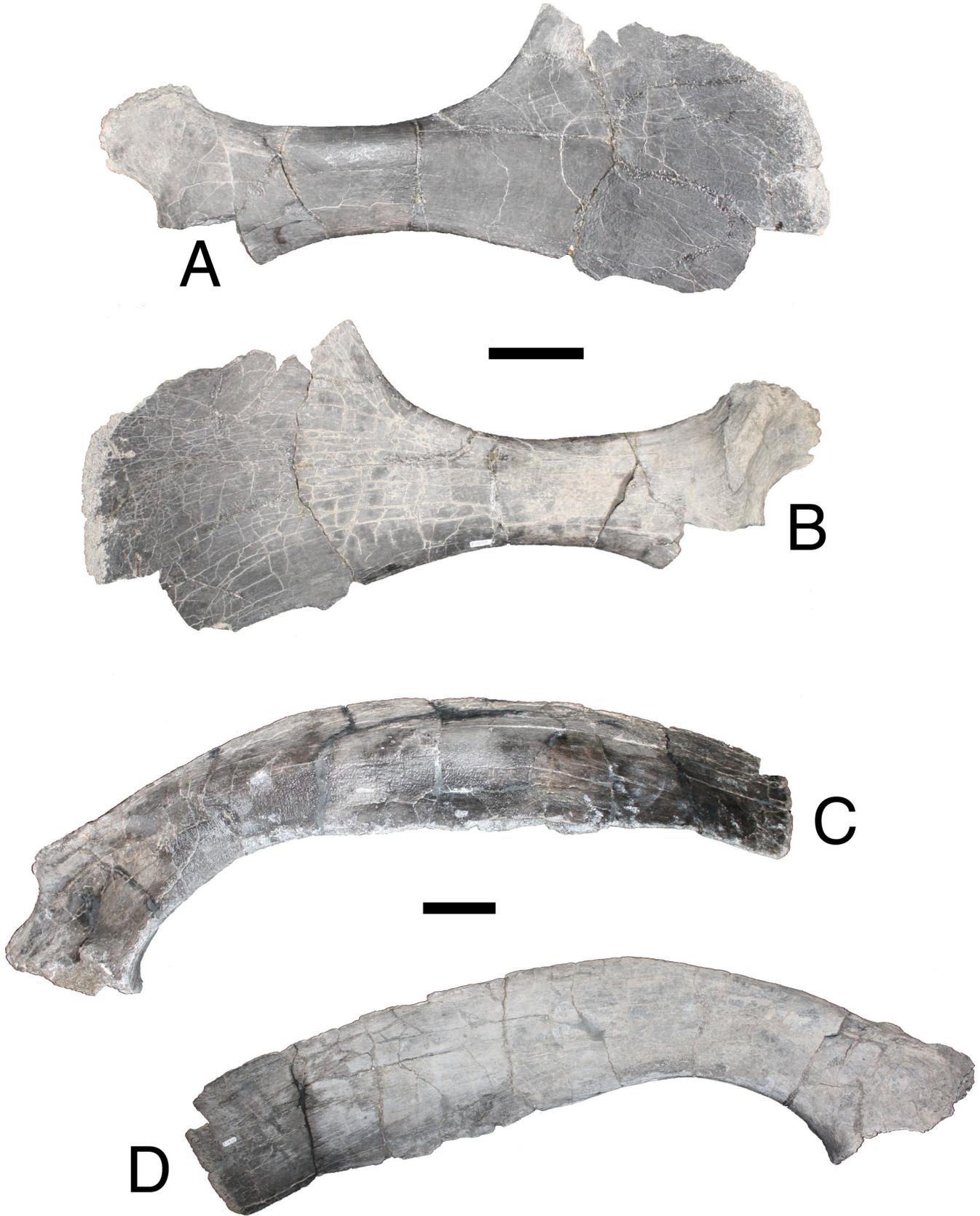


FIGURE 28. Lambeosaurini indeterminate. NMMNH P-19147, various postcrania. **A-B**, incomplete right pubis in **A**, lateral and **B**, medial views. **C-D**, nearly complete right scapula in **C**, medial and **D**, lateral views. Bar scales = 10 cm.

Naashoibito Member. Nevertheless, hadrosaurines are probably present, because they are known to occur in younger units elsewhere in North America, but none from the Naashoibito Member can be identified to the generic level.

**Ceratopsia Marsh, 1890**  
**Ceratopsidae Marsh, 1888**  
**Chasmosaurinae Lambe, 1915**  
***Ojoceratops* Sullivan and Lucas, 2010**  
***Ojoceratops fowleri* Sullivan and Lucas, 2010**  
**Figs. 29-30**

**Holotype:** SMP VP-1865, nearly complete left squamosal (Fig. 29A-B)

**Referred material:** NMMNH P-22884 (= UNM B-628), incomplete left squamosal; NMMNH P-36200, fragmentary skull elements, including sections of the squamosals, parietal, upper portion of the premaxilla (including the narial struts and the premaxillary fossa), and occipital condyle; NMMNH P-44477, partial parietal with attached epoccipital; SMP VP-1243, frill fragment and two other bone fragments; SMP VP-1245, frill fragments and other bone fragments; SMP VP-1246, frill fragments and other bone fragments; SMP VP-1248, frill fragment; SMP VP-1250, parietal fragment; SMP VP-1575, incomplete medial parietal bar (Fig. 30C); SMP VP-1576, frill fragments; SMP VP-1719, incomplete left jugal with other skull fragments and associated bone fragments; SMP VP-1828, nearly complete nasal complex (Fig. 29C-D), nearly complete rib, and frill fragments; SMP VP-1829, squamosal fragment, rostral, medial parietal bar, and associated bone fragments; SMP VP-1849, frill fragments; SMP VP-1872, ?frontal; SMP VP-1873, incomplete left dentary with associated bone fragments; SMP VP-1874, anterior portion of right ?nasal; SMP VP-1875, nearly complete right dentary (Fig. 30A-B) and nearly complete left scapula; SMP VP-1877, frill/parietal fragments; SMP VP-2013, medial parietal bar; SMP VP-2076, incomplete right scapula; SMP VP-2089, incomplete left pubis; SMP VP-2090, nearly complete prementary (Fig. 30D-E).

**Remarks:** Sullivan and Lucas (2010) established the taxon *Ojoceratops fowleri* based on a complete left squamosal, which is characterized as being wide and arched, having an enlarged base, with the otic notch embayment lost, and truncated (squared-off) distally. A number of specimens were identified as cf. *Ojoceratops fowleri* because they could not be referred to the type specimen and also because of the possible occurrence of another ceratopsid within the Naashoibito Member (Sullivan and Lucas, 2010). However, we are of the opinion that all this material, previously identified as cf. *O. fowleri*, is actually *Ojoceratops fowleri*.

Ceratopsid material has been known from the Naashoibito Member of the Ojo Alamo Formation since the early 1900's, but these specimens were relatively few. Brown (1910) and Gilmore (1916) reported "Monoclonius-like" remains, a small horn core (AMNH 5798) as coming from the "Ojo Alamo sandstone," but its light brown color and preservation is consistent with vertebrate fossils from the upper Fruitland and lower Kirtland Formation, not the Naashoibito Member. However, some isolated teeth and frill fragments have been cited as coming from the exposures along Barrel Springs above the lower conglomerate (Gilmore, 1916). In a subsequent paper, Gilmore (1919) noted other fragmentary specimens, including a skull (unnumbered), consisting of "a considerable part of what appears to be the median or dermosupraoccipital" with evidence of "a fenestrated frill in which the openings are apparently smaller" than known ceratopsids of that time (*Triceratops*, *Ceratops*, or *Monoclonius*) (Gilmore, 1919, p. 65). Gilmore (1919) concluded that "in all probability it represents an undescribed form."

For decades few supplemental ceratopsid specimens were collected from the Naashoibito Member since Gilmore's work. Many specimens previously cited as coming from the Naashoibito Member by Lehman (1981) are now known to have originated from the De-na-zin Member (Sullivan et al., 2005a). Recent collecting by the New Mexico

Museum of Natural History and Science and the State Museum of Pennsylvania has yielded numerous ceratopsid specimens from the Naashoibito Member, the majority of which we assign to *Ojoceratops*.

The specimens referred to *Ojoceratops fowleri* consist largely of cranial material. The only postcranial elements that have been recovered include two scapulae, a rib and a pubis. Notable cranial elements include a nearly complete nasal complex (SMP VP-1828, Fig. 29C-D), a nearly complete right dentary with coronoid process (SMP VP-1875, Fig. 30A-B), an incomplete medial (parietal) bar (SMP VP-1575, Fig. 30C), and nearly complete prementary (SMP VP-2090, Fig. 30D-E), among other skull elements (see Sullivan and Lucas, 2010).

Farke and Williamson (2006) reported on NMMNH P-44477 as pertaining to a distinct ceratopsid similar to *Triceratops*, but this specimen was referred to *Ojoceratops fowleri* by Sullivan and Lucas (2010). They tentatively referred NMMNH P-22884, an incomplete left squamosal, characterized by a smooth dorsal surface, and long basal attachment, as well as having a similar shape, to cf. *Ojoceratops fowleri* (Sullivan and Lucas, 2010). SMP VP-1719 (in part) was stated to consist of a right lacrimal (Sullivan and Lucas, 2010), but is here re-identified as an incomplete left jugal.

In a recent study, Longrich (2011) considers *Ojoceratops* to be synonymous with *Triceratops*. He states that *Ojoceratops* has numerous synapomorphies with *Triceratops* and that the diagnostic feature of the squamosal of *Ojoceratops* (a broad, squared-off end of the squamosal is "approached by at least one specimen of *Triceratops* (*Triceratops 'serratus,'* AMNH 970)" (Longrich, 2011). However, we reject his assessment and note that Longrich (2011) ignored the other diagnostic features of *Ojoceratops*, including an enlarged base, a lack of embayment of the otic notch, the squamosal being wide and arched, forming an angle of 115° at epijugal 1, a concave medial border, and a convex lateral border forming an arc of 80° (see Sullivan and Lucas, 2010). The parietal (medial) bar (Fig. 30C) is unique for *Ojoceratops fowleri* and is not seen in any *Triceratops* specimens. The presence or combination of these features supports *Ojoceratops* as a valid taxon. Moreover, geographic and stratigraphic differences also must be taken into consideration. *Ojoceratops fowleri* predates *Triceratops* by a few million years (see discussion below).

**Ceratopsidae indet.**

**Referred material:** NMMNH P-21100 (= UNM FKK-035), incomplete right squamosal; NMMNH P-25074 (= UNM FKK-013), postero-medial section of parietal; SMP VP-1459, two indeterminate frill fragments from margin of a juvenile or sub-adult; SMP VP-1533, basicranium fragments and bone fragments in "cannonball" concretion; SMP VP-1642, unidentified skull element; SMP VP-1714, centrum of dorsal vertebra; SMP VP-1830, unidentified bone; SMP VP-2047, unidentified element in four pieces; SMP VP-2088, vertebra centrum and associated bone fragments; SMP VP-2107, basicranium fragments; SMP VP-2262, incomplete right coronoid process; SMP VP-2509, 88 teeth and tooth fragments; SMP VP-2539, two ?squamosal fragments; SMP VP-2589, indeterminate skull fragments; SMP VP-2592, ?frontal fragment and indeterminate bone fragment; SMP VP-2693, tooth; SMP VP-2733, ?horn fragment.

**Remarks:** The majority of this ceratopsid material is very fragmentary and not diagnostic at the generic level. It is likely that most of it pertains to *Ojoceratops*.

*Pentaceratops* was cited as coming from the Naashoibito Member by some earlier workers (e.g., Lehman, 1981; Lucas et al., 1987). It was later found that either the stratigraphic placement of these specimens was erroneous, or that the identifications were questionable (Rowe et al., 1981; Lehman, 1993). The specimen NMMNH P-25084 (previously UNM FKK-035), identified as a juvenile of *Pentaceratops* cf. *P. sternbergii* (Lehman, 1981, 1985), is from the De-na-zin Member (Sullivan et al., 2005a). Although *Pentaceratops* has been reported in the De-na-zin Member as recently as 2006 (Sullivan and Lucas, 2006), the material

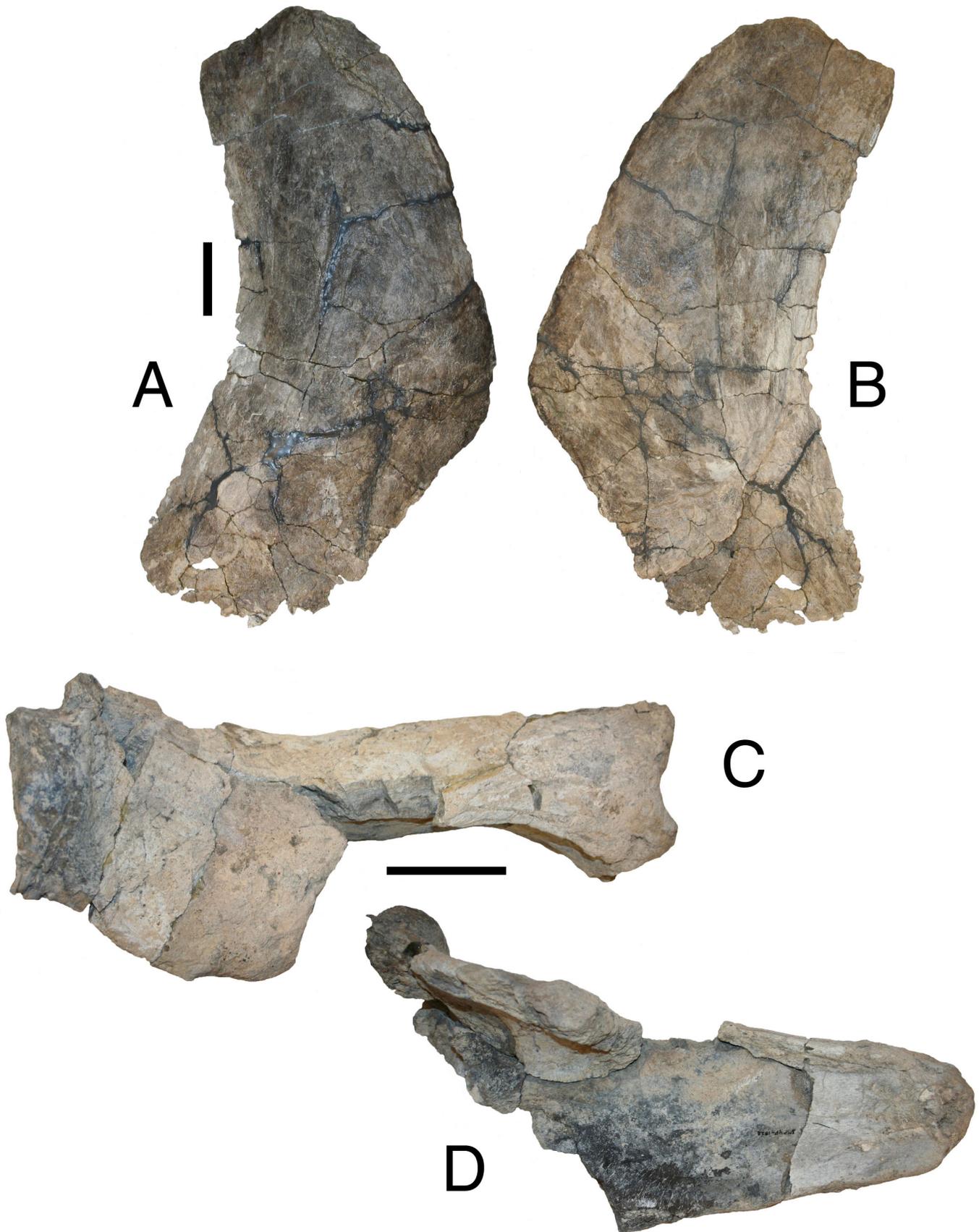


FIGURE 29. *Ojoceratops fowleri*. **A-B**, SMP VP-1865 (holotype), nearly complete left squamosal in **A**, lateral and **B**, medial views. **C-D**, SMP VP-1828, nearly complete nasal complex in **C**, right lateral and **D**, ventral views. Bar scales = 10 cm.

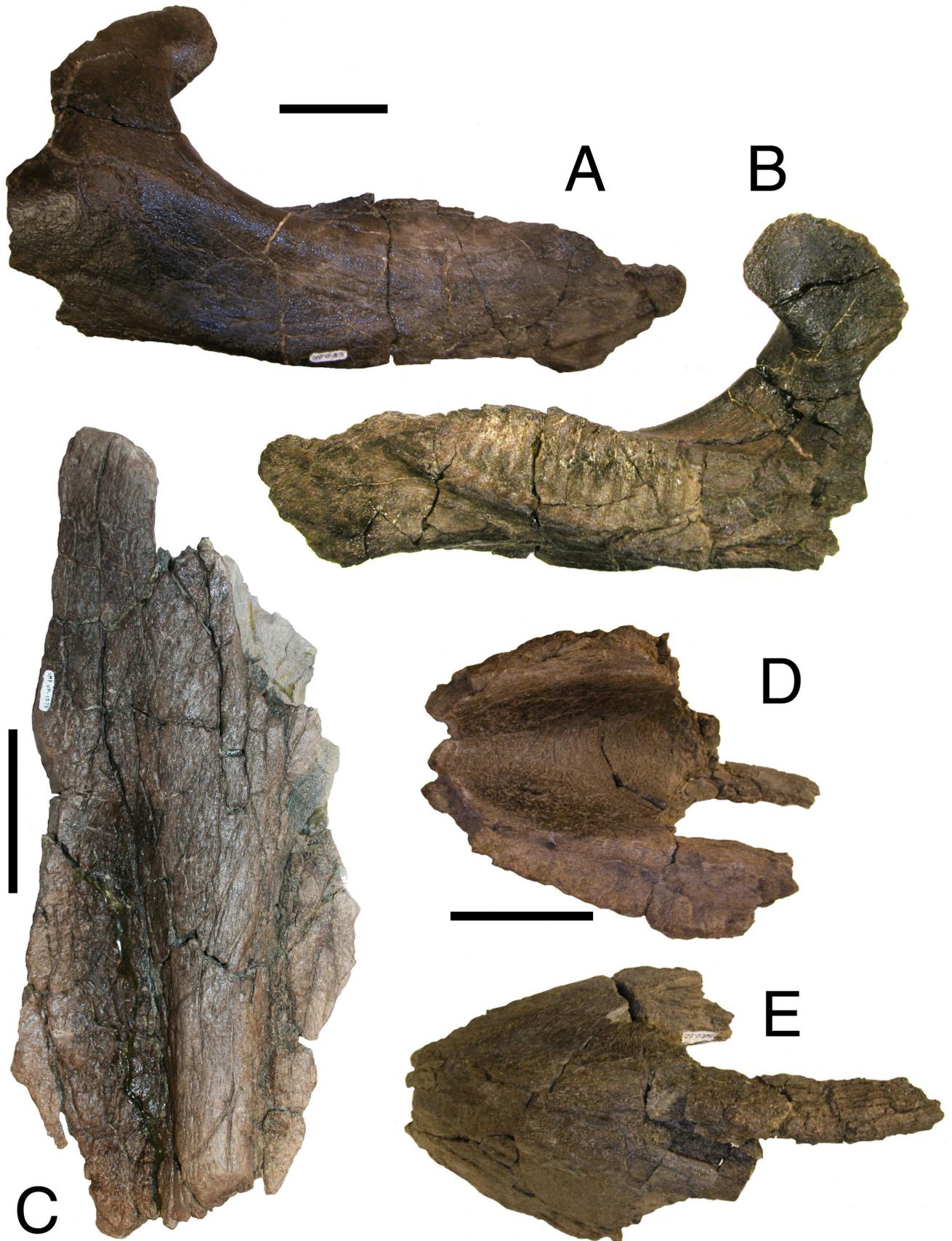


FIGURE 30. *Ojocerotops fowleri*. A-B, SMP VP-1875, nearly complete right dentary with coronoid process in A, lateral and B, medial views. C, SMP VP-1575, incomplete medial bar in dorsal view. D-E, SMP VP-2090, nearly complete prementary in D, occlusal and E, ventral views. Bar scales = 10 cm.

upon which this is based is inconsistent with *Pentaceratops* and is currently being re-assessed by us. Without question, *Pentaceratops* is not known from the Naashoibito Member. NMMNH P-25084 was identified as an indeterminate chasmosaurine (Sullivan et al., 2005a).

A postero-medial part of a parietal (NMMNH P-25074, previously UNM FKK-013) was identified as aff. *Torosaurus utahensis* (Lehman, 1981), *Torosaurus* cf. *utahensis* (Lehman, 1985), and later as *Torosaurus utahensis* (Lehman, 1993). The specimen has been determined to have come from the De-na-zin Member and has been identified as an indeterminate chasmosaurine (Sullivan et al., 2005a).

An incomplete left squamosal (NMMNH P-22884, previously UNM B-628) was identified as aff. *Torosaurus utahensis* (Lehman, 1981) and later as *Torosaurus* cf. *T. utahensis* (Lucas et al., 1987). It has been re-identified as an indeterminate chasmosaurine (Farke, 2002; Sullivan et al., 2005a).

A third specimen, NMMNH P-21100 (previously UNM FKK-031), an incomplete right squamosal, had been tentatively assigned to *Torosaurus* (e.g., Lehman, 1981, 1985) but is now considered to be an indeterminate chasmosaurine (Farke, 2002; Sullivan et al., 2005a; Sullivan and Lucas, 2010). Sullivan and Lucas (2010) stated that NMMNH P-21100 is distinct from *Ojoceratops fowleri* and suggested that it may represent a second taxon of ceratopsid in the Naashoibito Member. However, considering the excellent preservation of NMMNH P-21100, and the fact that many of the specimens collected in the 1970's purportedly originated from the Naashoibito Member, but later were determined to be from the De-na-zin Member, we remain skeptical about its stratigraphic occurrence. More specimens of this taxon, either from the De-na-zin or Naashoibito members, must be discovered in order to verify the stratigraphic horizon from which it came.

#### Dinosauria indet.

**Referred material:** SMP VP-1244, three indeterminate bone fragments; SMP VP-1820, vertebra fragment; SMP VP-1833, unidentified element; SMP VP-2066, proximal end of unidentified bone; SMP VP-2106, distal end of ?fibula; SMP VP-2108, unidentified element; SMP VP-2191, unidentified bone; SMP VP-2231, ?limb fragment; SMP VP-2261, ?skull fragment; SMP VP-2516, ?rib fragment; SMP VP-2591, postcranial element; SMP VP-2596, incomplete side of vertebra centrum and skull fragments; SMP VP-2627, ?ectopterygoid; SMP VP-2700, coprolite; SMP VP-2784, ?skull fragments and vertebrae fragments, SMP VP-2789, nearly complete rib; SMP VP-2808, ?incomplete vertebra and vertebrae fragments.

**Remarks:** Material identified as indeterminate dinosaur is fairly common and may eventually be identified by comparison with additional material.

#### MAMMALIA

##### Multituberculata Marsh, 1889

##### Neoplaguaulacidae Ameghino, 1890

##### *Mesodma* Jepsen, 1940

##### *Mesodma formosa* Marsh, 1889

**Material:** NMMNH P-49781 (= UALP 15641), left posterior half of P4; NMMNH P-49782 (= UALP 15644), posterior fragment of worn right M1; NMMNH P-49829 (= UALP 15642), left P4; NMMNH P-49830 (= UALP 15643), posterior half of right M1.

**Remarks:** *Mesodma* in the Naashoibito Member is represented by both premolars and molars (Flynn, 1986). *Mesodma formosa* has been identified from the early Paleocene (Puercan) Mammal Hill locality at Bettonie Tsosie Arroyo by Sloan (1981). Weil and Williamson (2004) state that the genus *Mesodma* is the only multituberculata mammal taxon present in the Campanian, Maastrichtian, and Paleocene, indi-

cating that it survived the Cretaceous-Tertiary boundary extinction. We note that this is an unusually long-lived species, assuming the species identifications of the specimens are correct, documenting this taxon from the Campanian through Puercan. We tentatively accept its presence in the AWlf based on the work of Flynn (1986), and note that it is of little biostratigraphic utility.

#### Eucoosmodontidae Jepsen, 1940

##### *Essonodon* Simpson, 1927

##### cf. *Essonodon* sp.

**Referred material:** NMMNH P-30243, M2 fragment; NMMNH P-32570, left M2; NMMNH P-32771, M1; NMMNH P-32773, left M2; UNM FKK-020, left M1.

**Remarks:** Lehman (1984) referred a single large, unworn left M1 (UNM FKK-020) to *Essonodon browni*. He stated that the tooth agreed “so strongly with Archibald’s (1982, fig. 31) figure and description of M1 in *E. browni*, there can be little doubt of their specific identity” (Lehman, 1984, p. 602). He also noted, though, that UNM FKK-020 was slightly smaller and had a more notched posterior margin (Lehman, 1984). This specimen, which was supposedly acquired by the NMMNH, could not be found and its disposition is currently unknown. Nevertheless, other specimens in the NMMNH paleontology collection have been identified as *Essonodon* sp. (NMMNH P-30243, P-32570, P-32771, and P-32773) and suggest its presence in the Alamo Wash local fauna, although we have not examined these specimens first-hand and verified their identifications. Pignataro et al. (2003) reported that *Essonodon* specimens from the Naashoibito Member are generally smaller than those reported elsewhere. We tentatively assign all these specimens to cf. *Essonodon* sp. pending further study.

#### Taeniolabidae Granger and Simpson, 1929

##### *Meniscoessus* Cope, 1882

##### aff. *Meniscoessus* sp.

**Referred material:** NMMNH P-49780 (= UALP 15640), right lower incisor fragment.

**Remarks:** Flynn (1986) took note “of a cimolomyid, perhaps close to *Meniscoessus robustus*” represented by the tip of a tooth. We have not seen the specimen upon which this identification is based and cannot comment further.

#### Multituberculata indet.

**Referred material:** NMMNH P-49783 (= UALP 15645), M2 fragment.

**Remarks:** Flynn (1986) reported on a tooth fragment (NMMNH P-49783 [= UALP 15645]) of a large M2 that he believed was too large for any species of *Mesodma*, and may have belonged to a species of *Cimolodon* or *Cimolomys*, but he did not specifically refer it to the family level or lower. Flynn (1986) also mentioned that “several fragmentary teeth suggest that at least one more species of *Mesodma* and two larger multituberculata were present,” although he did not provide any other data or specimen numbers. Pignataro et al. (2003) briefly mentioned a specimen of *Mesodma* sp. nov., but indicated that the identification was tentative and did not list a specimen number. Lehman (1984) also briefly mentioned multituberculata dP2’s (UNM FKK-037a+b), but did not refer them to anything more than indeterminate multituberculata and their current disposition is unknown. Pignataro et al. (2003) refer another specimen to an “apparently new, taxon,” but state it is “currently too incomplete for meaningful assignment” and do not give a specimen number or other data with it. Weil and Williamson (2004) report on a multituberculata from the Naashoibito Member, but also provided no additional data.

**Marsupialia Illiger, 1811**  
**Archimetatheria Szalay, 1993**  
**Pediomyidae Simpson, 1927**  
**cf. Pediomyidae indet.**

**Referred material:** NMMNH P-41557, left molar trigonid; NMMNH P-46395, upper left molar fragment; NMMNH P-54200, partial right P3.

**Remarks:** Williamson and Weil (2008a) tentatively referred NMMNH P-41557, P-46395, and P-54200 to *Pediomyidae*, but stated they could not provide a more precise identification. We have not seen this material and cannot comment on the taxonomic identification.

**Didelphimorphia Gill, 1827**  
**Didelphidae Gray, 1821**  
**Alphadontinae Marshall, Case and Woodburne, 1990**  
***Alphadon* Simpson, 1927**  
***Alphadon marshi* Simpson, 1927**

**Referred material:** NMMNH P-49828 (= UALP 13633), right M3; NMMNH P-49779 (= UALP 13634), left M2.

**Remarks:** Flynn (1986) identified two specimens (NMMNH P-49828 = UALP 13633 and NMMNH P-49779 = UALP 13634) as *Alphadon marshi*, a taxon known from the Lance Formation, but that they were more comparable in size to *A. russelli* (Clemens, 1966) and that the two specimens were indistinguishable from *A. marshi*, other than differences in size (Flynn, 1986). We tentatively retain these specimens as *A. marshi* and recognize them as part of the AWLF.

**Alphadontinae indet.**

**Referred material:** NMMNH P-41549, right P2 or P3.

**Remarks:** Williamson and Weil (2008a) refer to an indeterminate peradictid, on the basis of a single right P2 or P3 (NMMNH P-41549). They state it is "similar in morphology to ..... 'alphadontid' marsupials such as *Alphadon halleyi* ..... and *Alphadon eatoni*" (Williamson and Weil (2008a), and we consider it an indeterminate alphadontine.

**Paucituberculata Ameghino, 1894**  
**Glasbiidae Clemens, 1966**  
***Glasbius* Clemens, 1966**  
**aff. *Glasbius* sp.**

**Referred material:** NMMNH P-41560, upper molar fragment; NMMNH P-46380, right M2 or M3; NMMNH P-46381, right M4; NMMNH P-46384, upper molar fragment.

**Remarks:** Williamson and Weil (2006, 2008a) reported two specimens (NMMNH P-46380 and P-46381) as pertaining to *Glasbius* cf. *G. intricatus* based on similar size to those cited by Clemens (1966, 1973) and Archibald (1982). Williamson and Weil (2008a) also reported on two upper molar fragments (NMMNH P-46384, and P-41560), which they refer to cf. *Glasbius* sp. However, it is not clear to us that NMMNH P-46380 and 46381 are correctly assigned to *Glasbius*. Both teeth lack the extensive labial cingulid that would distinguish them from *Alphadon*; indeed, they resemble the teeth that Rigby and Wolberg (1987, pl. 3) assigned to *Alphadon* from the uppermost Fruitland Formation (Kirtlandian). Therefore, we only identify these teeth as aff. *Glasbius* sp.

**Vertebrata indet.**

**Referred material:** NMMNH P-32988, indeterminate bone fragment; SMP VP-2480, left frontal (Fig. 31A-B); SMP VP-2502, two coprolites (Fig. 31C-D); SMP VP-2512, two indeterminate bone fragments; SMP VP-2662, incomplete ?tooth; SMP VP-2695, two indeterminate bone fragments; SMP VP-2700, coprolite (Fig. 31E-F).

**Remarks:** Numerous indeterminate fossil vertebrate bones, many

of them fragmentary, are commonly encountered in the Naashoibito Member. Other specimens, while perhaps somewhat more complete, still defy identification.

**FAUNAL COMPOSITION OF  
 THE ALAMO WASH LOCAL FAUNA**

The Alamo Wash local fauna was first characterized by Lehman (1981) for vertebrate remains from the Naashoibito Member (then, but not now, considered part of the Kirtland Formation based on the work of Baltz et al., 1966). Lucas and Sullivan (2000) advocated returning to the original concept of the Ojo Alamo Sandstone (herein "Formation") described by Bauer in 1916 (Lucas and Sullivan, 2000a; Sullivan et al., 2005b; also see Fassett, 2009 and references cited therein). A schematic stratigraphic section of the Naashoibito Member, in relation to its adjacent units, is presented in Fig. 32.

Fossil vertebrates from the Naashoibito Member were largely neglected between the early 1920s and 1970s. The revival of collecting of fossil vertebrates from the Naashoibito Member was executed by the 1977 BLM Survey (Kues et al., 1977). Subsequent, and limited, field excursions were followed up by students and faculty from the University of New Mexico, University of Arizona and others. However, it wasn't until 1995 that the State Museum of Pennsylvania began a systematic collecting program targeting the Kirtland and Ojo Alamo formations. Nearly two decades of collecting fossil vertebrates in the De-na-zin Member (Kirtland Formation) and the Naashoibito Member (Ojo Alamo Formation) has enabled us to precisely record and verify the occurrences of new and previously known taxa within these two stratigraphic units. Historically, there had been confusion, especially near their common boundary, regarding the precise stratigraphic horizon of some key taxa, such as *Naashoibitosaurus*, *Parasaurolophus tubicen* and *Kritosaurus* (= *Hadrosaurus*) *navajovius*. The stratigraphic provenance of these taxa has now been resolved by our re-sampling of these units. In addition, new and additional taxa recovered from both units further serve to distinguish the Willow Wash local fauna from the Alamo Wash local fauna. While the faunas of the Kirtland Formation (Hunter Wash local fauna and the younger Willow Wash local fauna) have been recently documented in detail (Sullivan and Lucas, 2006), the Alamo Wash local fauna has not. Thus, the current article is the first major revision of the Alamo Wash local fauna since Lehman (1981), made possible by our continuing field efforts and, to a lesser extent, by the work of others, notably Flynn (1986), Williamson and Weil (2001a, 2004, 2006, 2008a), Weil and Williamson (2004) and Weil et al. (2006).

Lehman (1981) reported and listed turtles, crocodylians, and dinosaurs as the principal taxa comprising the Alamo Wash local fauna. Of the turtle genera he recognized, only *Compsemys*, *Hoplochelys* and *Basilemys* actually occur in the Naashoibito Member based on subsequent collecting and other studies (Lucas and Sullivan, 2006; Sullivan et al., in press). The specimens Lehman (1981) cited as "*Aspideretes*" are now known to be from the De-na-zin Member, based on their preservation (Sullivan et al., in press). There are however, trionychids from the Naashoibito Member, but only one, based on a single right parietal (SMP VP-2517: Fig. 4A), may be identifiable to genus (cf. *Plastomenus* sp.).

Crocodylians reported by Lehman (1981) include *Goniopholis* (now *Denazinosuchus*: Lucas and Sullivan, 2003), which is believed to be from the De-na-zin Member, not the Naashoibito Member. The molariform teeth that Lehman (1981) identified as *?Allognathosuchus* most likely belong to *Brachychampsa* sp. The taxon *Crocodylus* is not known from the Cretaceous strata of the San Juan Basin.

A few dinosaurs were identified by Lehman (1981), and we now know a number of them were incorrectly identified. These include the tyrannosaurid *?Albertosaurus*, which we now know may include a tyrannosaurid taxon as large as *Tyrannosaurus*, but not necessarily *T. rex*. The purported hypsilophodontid is now known to be *Alamosaurus sanjuanensis*, an identification Lehman (1981) made based on an incomplete scapula from a juvenile or subadult individual. There is no evidence

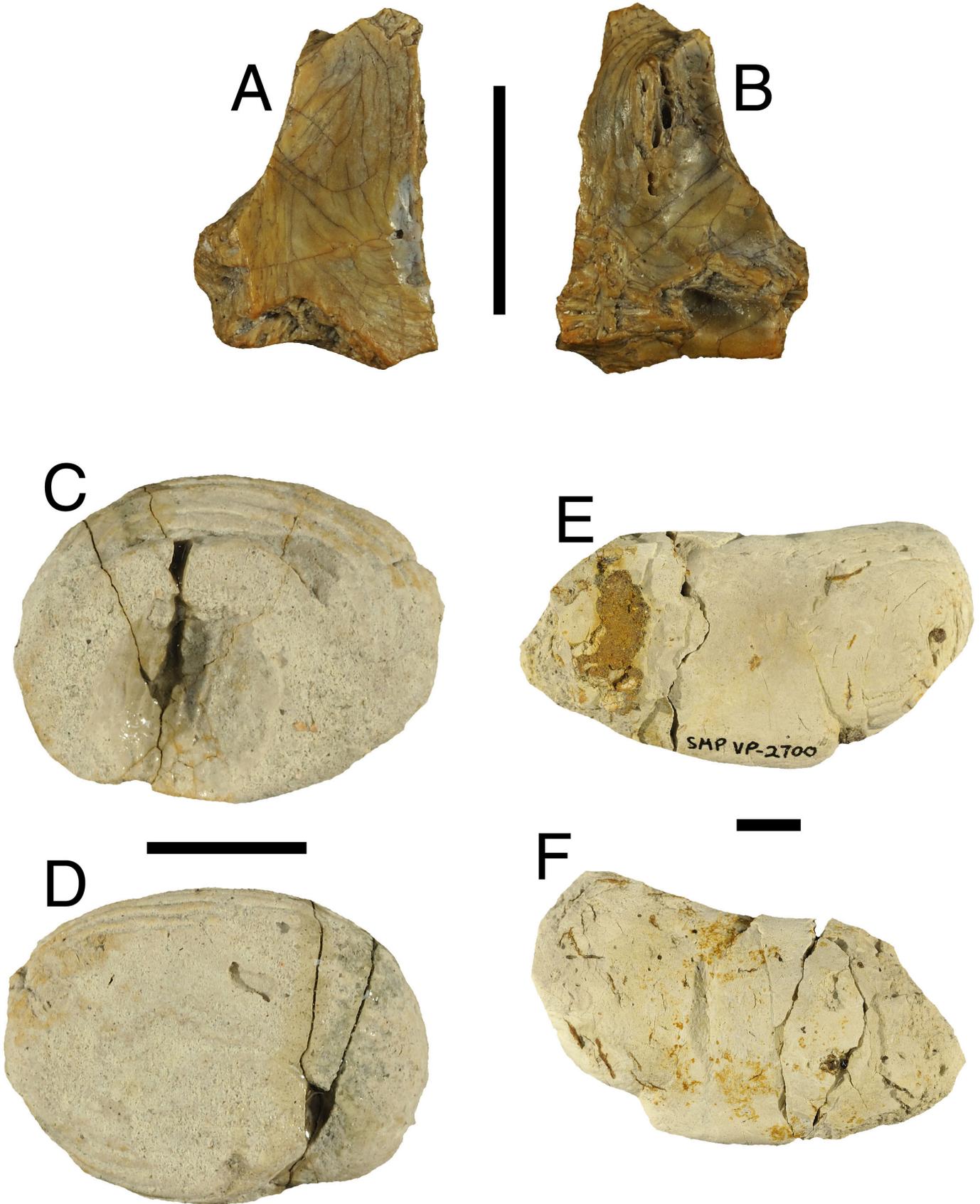


FIGURE 31. Vertebrata indeterminate. SMP VP-2480, left frontal in **A**, dorsal and **B**, ventral view. **C-D**, SMP VP-2502, coprolite in opposite views. **E-F**, SMP VP-2700, coprolite in opposite views. Bar scales = 1 cm.

TABLE 1. Alamo Wash local fauna. Faunal list of Lehman (1981) compared to ours (this study). The taxonomic identities are presented in their original form as per Lehman (1981); \*denotes tentative occurrence and \*\*denotes that the taxon is exclusively from the underlying De-na-zin Member (Kirtland Formation) and not from the Naashoibito Member (Ojo Alamo Formation).

Lehman, 1981	This Paper	Lehman, 1981	This Paper
	<b>Chondrichthyes</b> <i>Myledaphus</i> sp. <i>?Squatirhina</i> sp.*		<b>Coelurosauria</b> <i>Richardoestesia</i> sp.*
	<b>Osteichthyes</b> <i>Lepisosteidae</i> indet.	<b>Tyrannosauridae</b> <i>?Albertosaurus</i> sp.	<b>Tyrannosauridae</b> Tyrannosauridae indet.
	<b>Caudata</b> <i>?Batrachosauridae</i> indet.		<b>Ornithomimidae</b> Ornithomimidae indet.
	<b>Pleurosternidae</b> <i>Compsemys</i> sp.		<b>Caenagnathidae</b> <i>Ojoraptorsaurus boerei</i> Caenagnathidae indet.
<b>Baenidae</b> "Baena" <i>nodosa</i> <i>Thescelus insiliens</i> <i>Neurankylus eximius</i> <i>Compsemys</i> sp.	<b>Baenidae</b> Baenidae indet.		<b>Troodontidae</b> Troodontidae indet.
	<b>?Kinosternidae</b> <i>Hoplochelys</i> sp.		<b>Dromaeosauridae</b> Dromaeosauridae indet.
	<b>Adocidae</b> Adociidae indet.	<b>Saurornithoididae</b> gen. et sp. indet.	
	<b>Nanhsiungchelyidae</b> <i>Basilemys</i> sp.	<b>Titanosauridae</b> <i>Alamosaurus sanjuanensis</i>	<b>Titanosauridae</b> <i>Alamosaurus sanjuanensis</i>
		<b>Hypsilophodontidae</b> gen. et sp. indet.	
<b>Dermatemyidae</b> <i>Adocus vigoratus</i> <i>Basilemys nobilis</i> <i>Hoplochelys</i> cf. <i>H. bicarinata</i>		<b>Nodosauridae</b> <i>?Panoplosaurus</i> sp.	<b>Nodosauridae</b> <i>Glyptodontopelta mimus</i>
<b>Trionychidae</b> <i>Aspideretes vorax</i> <i>Aspideretes fontanus</i> <i>Aspideretes austerus</i>	<b>Trionychidae</b> cf. <i>Plastomenus</i> sp. Trionychidae indet.	<b>Hadrosauridae</b> <i>Hadrosaurus navajovius</i> ** <i>Parasaurolophus tubicen</i> **	<b>Ankylosauridae</b> Ankylosauridae indet.
	<b>Teiidae</b> <i>?Chamops</i> sp.* <i>?Peneteius</i> sp.*	<b>Hadrosauridae</b> <i>Hadrosaurus navajovius</i> ** <i>Parasaurolophus tubicen</i> **	<b>Hadrosauridae</b> Lambeosaurini indet. Hadrosauridae indet.
	<b>Alligatoridae</b> cf. <i>Brachychampsa</i> sp.	<b>Ceratopsidae</b> <i>Pentaceratops sternbergii</i> ** aff. <i>Torosaurus utahensis</i>	<b>Ceratopsidae</b> <i>Ojoceratops fowleri</i> Ceratopsidae indet.
<b>Crocodylidae</b> <i>Crocodylus</i> sp. <i>?Alloganthosuchus</i> sp.	<b>Crocodylidae</b> Crocodylidae indet.		<b>Neoplaguaulacidae</b> <i>Mesodma formosa</i>
			<b>Eucosmodontidae</b> cf. <i>Essosodon</i> sp.
<b>Goniopholididae</b> <i>Goniopholis</i> sp.			<b>Taeniolabidae</b> aff. <i>Meniscoessus</i> sp.
			<b>Pediomyidae</b> cf. <i>Pediomyidae</i> indet.
			<b>Didelphidae</b> <i>Alphadon marshi</i> Alphadontinae indet.
			<b>Paucituberculata</b> aff. <i>Glasbicus</i> sp.*

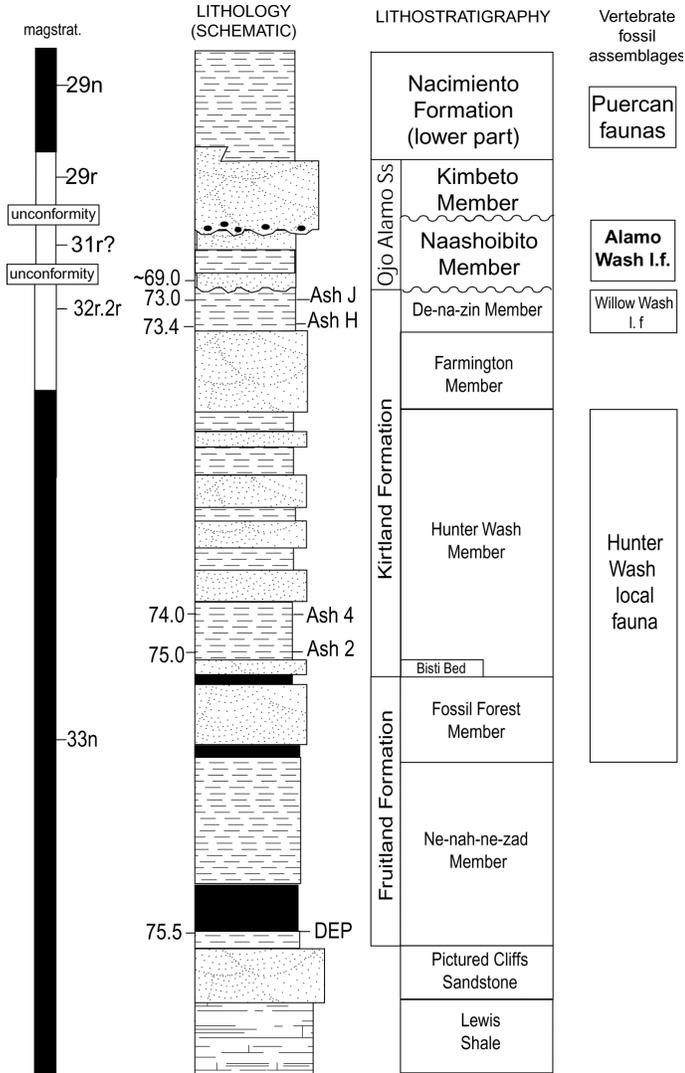


FIGURE 32. Stratigraphic schematic of the Naashoibito Member, Ojo Alamo Formation, relative to the other Upper Cretaceous and Paleocene formations, San Juan Basin, New Mexico. The numbers on the left side of the lithology schematic refer to millions of years ago. Ash dates are from Fassett and Steiner (1997), and the 69 Ma date (base of the Naashoibito) is from Sullivan et al. (2005a,b) and Sullivan and Lucas (2006) based on correlation to *Alamosaurus sanjuanensis* in the Big Bend region of Texas.

for *Panoplosaurus* in the Naashoibito: the only nodosaurid known is *Glyptodontopelta mimus*. The specimen (USNM 8571) upon which he based his ?*Panoplosaurus* identification may pertain to *G. mimus*. The two hadrosaurids Lehman cites (“*Hadrosaurus*” = *Kritosaurus navajovius* and *Parasaurolophus tubicen*) are both known from the De-na-zin Member, not the Naashoibito Member (Sullivan and Williamson, 1999; Williamson, 2000). Only an indeterminate lambeosaurin lambeosaurine, similar to *Corthyosaurus*, is known from the Naashoibito Member (Sullivan et al., 2011a). Lehman (1981) recognized two ceratopsids from the Naashoibito Member, *Pentaceratops sternbergii* and aff. *Torosaurus utahensis*. The former was based on NMMNH P-25084 (previously UNM FKK-035), which is not *Pentaceratops* and is from the De-na-zin Member (Sullivan et al., 2005a). The latter (aff. *Torosaurus utahensis*) was based on two specimens NMMNH P-22884 (previously UNM B-628), an incomplete left squamosal purportedly from the Naashoibito Member, and NMMNH P-25074, a postero-medial part of a parietal, from the De-na-zin Member. Both specimens are considered to be indeterminate chasmosaurine (Sullivan et al., 2005a). The only ceratopsid known with certainty from the Naashoibito Member is *Ojoceratops fowleri* (Sullivan and Lucas, 2010).

Lehman (1981) did not report fishes or mammals from the Alamo Wash local fauna and presented a faunal list that only included turtles, crocodylians and dinosaurs. Various mammals (multituberculates, marsupials, paucituberculates) were subsequently reported by Lehman (1984), Flynn (1986), Pignataro et al. (2003) Weil and Williamson (2004), and Williamson and Weil (2006, 2008a). Table 1 presents a list of vertebrate taxa comparing that of Lehman (1981) to ours based on this study.

### THE AGE OF THE ALAMO WASH LOCAL FAUNA

The precise age of the fossil vertebrates from the Naashoibito Member has been very contentious. The problem stems in part from the fact that there has been no precise way to derive a numerical age from the strata in which the Alamo Wash fauna occurs. Methodologies, including vertebrate biostratigraphy, magnetostratigraphy, palynostratigraphy, and bone geochemistry have all been the focus of debate. There are basically three points of view concerning the age of the Naashoibito Member and the Alamo Wash local fauna, that they are of: (1) Paleocene age; (2) late Maastrichtian age; or (3) early Maastrichtian age. Here we summarize these arguments.

#### Arguments for a Paleocene Age

The extraordinary claim that the Naashoibito Member, and the vertebrate fauna within it, is of Paleocene age, was put forth in a series of articles spearheaded by James E. Fassett (Fassett et al., 2000, 2006, 2011; Fassett, 2009). These arguments have been discussed in detail and countered by Sullivan et al. (2000, 2003), McKenna (2007), Lucas et al. (2009) and Koenig et al. (2011). At issue was the initial claim that Paleocene pollen occurred directly beneath dinosaur fossils in the Naashoibito Member (see Fassett, 2009). However, despite repeated attempts to duplicate this, no Paleocene pollen has been recovered from the Naashoibito Member or underlying strata (Sullivan et al., 2005b; Lucas et al., 2009, 2010). Paleomagnetic analysis put forth by Fassett (2009) is, in part, a reinterpretation of a spurious normal overprint that had been rejected by Lindsay et al. (1981) and Butler and Lindsay (1985), who were the original investigators. Moreover, a short normal polarity chron within a reverse polarity chron that corresponds to the Ojo Alamo Formation, does not mean that the Naashoibito Member cannot be of Cretaceous age (Lucas et al., 2009). The recent U-Pb age of ~ 64-65 Ma of a dinosaur bone from the Naashoibito Member reported by Fassett et al. (2011) is based on an unproven and unsound methodology (Koenig et al., 2011).

#### Arguments for a Late Maastrichtian Age

In the 1980s, most workers assigned the AWIf a Lancian (late Maastrichtian) age based primarily on the presence of *Alamosaurus*, *Tyrannosaurus* and *Torosaurus* (e.g., Lehman, 1981; Lucas et al., 1987). However, two of these taxa (*Tyrannosaurus* and *Torosaurus*) are not present (with certainty) in the AWIf (see above), and *Alamosaurus* is not a Lancian index taxon. More recently, the argument that the Naashoibito Member is late Maastrichtian in age has largely been put forth in a couple of papers, but mostly in abstracts, by Williamson and colleagues (Williamson and Weil, 2000, 2008a; Pignataro et al., 2003). The main issues here are: (1) equating the time interval of the Lancian to that of the late Maastrichtian, thus expanding the definition of the Lancian; (2) recognition of ad hoc “index taxa” for the Lancian without accepting the possibility that these “index taxa” are not restricted to the Lancian but occur earlier, beyond the recognized lower limits of the established Lancian time interval; and (3) their identification of the AWIf mammal taxa.

There is no real agreement as to the subdivision of the Maastrichtian Stage and the criteria used to subdivide it vary (Ogg et al., 2004). Nonetheless, in their correlation chart Ogg et al. (2004, p. 355) placed the boundary between the lower and upper Maastrichtian at 69.2 Ma. We note that Williamson and Weil (2008a) chose to literally accept the boundary between the Lancian and the “Edmontonian” based on the correlation chart of Cifelli et al. (2004, fig. 2.1) without regard to the fact

that the shaded boundary in that chart indicates it as an approximation. Cifelli et al. (2004, p. 32) clearly pointed out that the maximum duration for the Lancian, based on limited data from the Hell Creek Formation, is about 2 million years (67.61–65.58 Ma). Thus, the Lancian, only encompasses part of late Maastrichtian time.

Criteria for establishing index taxa is often problematic due to uncertainties regarding the first (and last) occurrences of taxa. This is further complicated by being able to unambiguously recognize index species based on fragmentary remains. Claims of the occurrence of *Tyrannosaurus rex* in the Naashoibito Member and North Horn Formation (Utah) have not been unequivocally established (*contra* Sampson and Loewen, 2005), and even if the taxon is present, it does not necessarily indicate a Lancian age for these units because it could represent an earlier unknown occurrence of that species. Moreover, it is not at all surprising that there would be evidence of a large *Tyrannosaurus*-like species prior to *T. rex*.

Williamson and Weil (2008a) described a number of mammalian fossils (mostly tooth fragments that cannot be identified at the genus or species level) that they claim indicate a Lancian age of the Naashoibito Member. Only two of these teeth, NMMNH P-463080 and 463081, identified as *Glasbius* cf. *G. intricatus*, may be of biostratigraphic significance (though identification of these teeth as *Glasbius* is open to question: see above). However, Williamson and Weil (2008a, p. 807) wrote “We refrain from making the referral more than a tentative one because of the small sample size and the lack of complete upper teeth from our assemblage with which to make a more thorough comparison.” Yet, based on these uncertain identifications they claim the presence of *Glasbius* in the Naashoibito Member and claim that the genus *Glasbius* is an index taxon of the Lancian. Sullivan and Lucas (2006, p. 20) noted that the occurrence of the marsupial genus *Alphadon*, a mammal taxon known from the type Lance fauna (Lancian), is also present throughout the Kirtland Formation (upper Campanian), which is Kirtlandian “age” or pre-“Edmontonian” and is not Lancian age.

Also, the questionable reports of the presence of the multituberculate species “*Essonodon browni*” in the Naashoibito Member (Lehman, 1984; Williamson and Weil, 2000; Pignataro et al., 2003) are not well supported (Sullivan et al., 2005b) and thus not definitive of a Lancian age. The fact that there has been so much uncertainty with respect to the identity of nearly all of the isolated mammalian teeth reported from the Naashoibito Member (Lehman, 1984; Flynn, 1986; Williamson and Weil, 2000, 2008a) undermines their reliable use in Upper Cretaceous biostratigraphy. However, it is clear that these teeth are not from Paleocene mammals, thus they are important indicators that the stratum from which they came is of Late Cretaceous age.

#### Arguments for an Early Maastrichtian Age

The unique dinosaur fauna from the Naashoibito Member, the lambeosaurines (which are not known in North America during the late Maastrichtian), coupled with the correlation of *Alamosaurus sanjuanensis* to Big Bend strata (dated at approximately 69 Ma), a date essentially agreed on by Williamson and Weil (2009), indicate the age of the Naashoibito Member and the Alamo Wash local fauna is no younger than late early Maastrichtian (Sullivan et al., 2005a,b; Sullivan and Lucas, 2006; Lucas et al., 2009). We thus regard this fauna as being temporally distinct from the younger Lancian fauna to the north and not a southern, endemic, Lancian time-equivalent assemblage. The lack of significant geographic barriers during the early Maastrichtian in that part of “Laramida” preclude it from being some isolated southern fauna, contrary to Pignataro et al. (2003) and Williamson and Weil (2008a). The fact that there are similar dinosaurs (a large tyrannosaurid) and a couple of similar mammals (“*Glasbius*” sp. and *Essonodon* cf. *E. browni*, herein considered cf. *E. sp.*), does not necessarily indicate isochroneity between the Lance/Hell Creek (Lancian) faunas and that of the AWlf. The data indicate that there is much as two million years between the AWLF and the type Lancian faunas.

## SUMMARY AND CONCLUSIONS

Due to confusion in stratigraphy, some fossils formerly attributed to the Naashoibito Member are actually from the underlying De-na-zin Member (Kirtland Formation). Consequently, earlier faunal lists (Alamo Wash local fauna) from the Naashoibito Member (Ojo Alamo Formation) included taxa actually from the De-na-zin Member, including: cyprinid fishes, the turtles *Denazinemys*, *Thescelus*, *Aspideretoides fontanus*, *A. austerus*, and *A. vorax*, *Goniopholis*, “*Crocodylus*,” *Albertosaurus*, *Tyrannosaurus rex*, ?*Panoplosaurus*, Hypsilophodontidae indeterminate, *Kritosaurus navajovius*, *Naashoibitosaurus ostromi*, *Parasaurolophus tubicen*, *Pentaceratops*, aff. *Torosaurus utahensis*, and *Torosaurus* cf. *T. utahensis*. Williamson (1998, p. 54) briefly reviewed the dinosaurs of the Alamo Wash local fauna (AWlf) and noted the presence of “*Alamosaurus sanjuanensis*, the chasmosaurine ceratopsian *Torosaurus* cf. *T. utahensis*, indeterminate hadrosaur, indeterminate ankylosaur, a large tyrannosaurid similar to *Tyrannosaurus rex*, and a small theropod tentatively identified as a dromaeosaur.” Lucas et al. (2000, p. 88) published the most recent list of dinosaurian taxa from the Naashoibito Member, which included; “indeterminate ornithomimid, dromaeosaurid, and saurornithoidids, ?*Albertosaurus* sp., cf. *Tyrannosaurus* sp., the sauropod *Alamosaurus sanjuanensis*, indeterminate ankylosaurid and nodosaurids, the ceratopsians *Torosaurus* cf. *T. latus* and *Pentaceratops* and at least one hadrosaurid.”

We conclude that the Alamo Wash local fauna currently includes the fishes *Myledaphus* sp., ?*Squatirhina* sp., Lepisosteidae indet., an indeterminate osteichthyan; the amphibian ?*Batrachosauroididae* indeterminate; turtles represented by the pleurosternid *Compsemys* sp., indeterminate baenids, the questionable kinosternoid *Hoplochelys* sp., an indeterminate adocid, the nanhsiungchelyid ?*Basilemys* sp., the trionychid *Plastomenus* sp., and indeterminate trionychids; the teiids ?*Chamops* sp. and *Peneteius* sp.; and crocodylians including cf. *Brachychampsa* and indeterminate crocodylids. Various dinosaurs are present, including the problematic coelurosaurian *Ricardoestesia* sp., the tyrannosaurid cf. *Tyrannosaurus* sp., indeterminate tyrannosaurids, indeterminate ornithomimids, the caenagnathid *Ojoraptorsaurus boerei*, an indeterminate troodontid, a new dromaeosaurid, indeterminate theropods, the titanosaur *Alamosaurus sanjuanensis*, the nodosaurid *Glyptodontopelta mimus*, an indeterminate ankylosaurid, an indeterminate lambeosaurine, indeterminate hadrosaurines, the chasmosaurine *Ojoceratops fowleri*, and indeterminate ceratopsids. Mammals include the neoplagiaulacid *Mesodma formosa*, the eucosmodontid cf. *Essonodon* sp., the taeniolabidid aff. *Meniscoessus*, an indeterminate pediaomyid, the alphadontin *Alphadon marshi*, and the glasbiid aff. *Glasbius*.

The Naashoibito Member is considered part of the Ojo Alamo Formation. An unconformity lies below the member, and correlation of this unit with *Alamosaurus*-bearing beds elsewhere indicate an age of approximately 69 Ma (pre-Lancian or Edmontonian). The fauna and stratigraphic unit are important stratigraphically, geographically, and temporally. Rich fossil-bearing beds lie below the Naashoibito Member, where the Paleocene strata and fossils lie. Further sampling will, undoubtedly, lead to more knowledge of the stratigraphy and age of the Naashoibito Member and its under- and overlying stratigraphic units, together with a more thorough view of the fauna comprising this important unit.

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## APPENDIX - ALAMO WASH LOCAL FAUNA SPECIMENS BY LOCALITY

INSTITUTION	LOCALITY#	GENUS	SPECIES	SPECIMEN NUMBER
NMMNH	314			
		Lambeosaurinae indet.		NMMNH P-19147
	929			
		<i>Squatirhina</i>	sp.	NMMNH P-27832
		? <i>Chamops</i>	sp.	NMMNH P-15017
		Ornithomimidae indet.		NMMNH P-22660
		Troodontidae indet.		NMMNH P-22566
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-27291
	1463			
		<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-14266
	1585			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-22544
	1611			
		Crocodylidae indet.		NMMNH P-20522
	1671			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-28741
	1672			
		Ankylosauridae indet.		NMMNH P-22654
	1759			
		Ceratopsidae indet.		NMMNH P-22884
	2191			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29031
	2349			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-25072
	3332			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-25077
	3335			
		Theropoda indet.		NMMNH P-28367
		Theropoda indet.		NMMNH P-28369
		Ceratopsidae indet.		NMMNH P-21100
	3355			
		<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-27849
	3499			
		Crocodylidae indet.		NMMNH P-32838
	3533			
		<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-25063
	3921			
		<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-27405
	3961			
		Tyrannosauridae indet.		NMMNH P-7199
	4005			
		<i>Myledaphus</i>	sp.	NMMNH P-44485
		<i>Peneteius</i>	sp.	NMMNH P-36544
		<i>Peneteius</i>	sp.	NMMNH P-41223
		<i>Peneteius</i>	sp.	NMMNH P-41224
		<i>Richardoestesias</i>	sp.	NMMNH P-32742
		<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-33917
		<i>Essonodon</i>	sp.	NMMNH P-32570
		<i>Essonodon</i>	sp.	NMMNH P-32771
		<i>Essonodon</i>	sp.	NMMNH P-32773
		cf. <i>Pediomyidae</i> indet.		NMMNH P-41557
		cf. <i>Pediomyidae</i> indet.		NMMNH P-46395
	cf. <i>Pediomyidae</i> indet.		NMMNH P-54200	
	Alphadontinae indet.		NMMNH P-41549	
	<i>Glasbius</i>	sp.	NMMNH P-41560	
	<i>Glasbius</i>	sp.	NMMNH P-46380	
	<i>Glasbius</i>	sp.	NMMNH P-46381	
	<i>Glasbius</i>	sp.	NMMNH P-46384	
	Vertebrata indet.		NMMNH P-32988	
4013				
	<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-27450	

	4014			
		<i>Glyptodontopelta</i>	<i>mimus</i>	NMMNH P-27420
	4120			
		<i>Hoplochelys</i>	sp.	NMMNH P-29159
	4224			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29722
	4225			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29725
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29726
	4226			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29724
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29727
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-29728
	4276			
		<i>Essonodon</i>	sp.	NMMNH P-30243
	4533			
		Ornithomimidae indet.		NMMNH P-38482
	4534			
		?Batrachosauroidea indet.		NMMNH P-44917
	4726			
		<i>Ojoceratops</i>	<i>fowleri</i>	NMMNH P-36200
	5222			
		Ornithomimidae indet.		NMMNH P-37811
	5841			
		<i>Ojoceratops</i>	<i>fowleri</i>	NMMNH P-44477
	6340			
		<i>Mesodma</i>	<i>formosa</i>	NMMNH P-49781
		<i>Mesodma</i>	<i>formosa</i>	NMMNH P-49782
		cf. <i>Meniscoessus</i>	sp.	NMMNH P-49780
		Multituberculata indet.		NMMNH P-49783
		<i>Alphadon</i>	<i>marshi</i>	NMMNH P-49779
	6501			
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	NMMNH P-49967
	6622			
		<i>Mesodma</i>	<i>formosa</i>	NMMNH P-49829
		<i>Mesodma</i>	<i>formosa</i>	NMMNH P-49830
		<i>Alphadon</i>	<i>marshi</i>	NMMNH P-49828
SMP				
	309b			
		Trionychidae indet.		SMP VP-2031
	313b			
		Tyrannosauridae indet.		SMP VP-1848
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1718
		<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1849
	319b			
		<i>Compsemys</i>	sp.	SMP VP-2590
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1138
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1139
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1494
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1539
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1541
		<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1876
		Ankylosauridae indet.		SMP VP-2632
		<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1877
		Ceratopsidae indet.		SMP VP-1459
		Ceratopsidae indet.		SMP VP-2589
		Ceratopsidae indet.		SMP VP-2592
		Dinosauria indet.		SMP VP-2591
		Dinosauria indet.		SMP VP-2627
	359			
		Ceratopsidae indet.		SMP VP-2733

360b			
	<i>Compsemys</i>	sp.	SMP VP-2527
	Baenidae indet.		SMP VP-2594
	Baenidae indet.		SMP VP-2637
	Trionychidae indet.		SMP VP-2173
	Trionychidae indet.		SMP VP-2234
	Tyrannosauridae indet.		SMP VP-2174
	Caenagnathidae indet.		SMP VP-2172
	Dromaeosauridae indet.		SMP VP-2595
	Theropoda indet.		SMP VP-2176
	Theropoda indet.		SMP VP-2521
	Theropoda indet.		SMP VP-2626
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2175
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2230
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2232
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2233
	Ankylosauridae indet.		SMP VP-1249
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1250
	Dinosauria indet.		SMP VP-2231
	Dinosauria indet.		SMP VP-2596
363b			
	Paracryptodira indet.		SMP VP-2670
	Trionychidae indet.		SMP VP-2078
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-2077
	Ceratopsidae indet.		SMP VP-2539
364b			
	<i>Hoplochelys</i>	sp.	SMP VP-1578
	Trionychidae indet.		SMP VP-1577
	Trionychidae indet.		SMP VP-1998
	Trionychidae indet.		SMP VP-1999
	Trionychidae indet.		SMP VP-3256
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1581
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1582
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1580
	Ankylosauria indet.		SMP VP-1731
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1576
366			
	Trionychidae indet.		SMP VP-1096
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1147
370b			
	cf. <i>Lepisosteus</i>	sp.	SMP VP-2501
	cf. <i>Lepisosteus</i>	sp.	SMP VP-2858
	Baenidae indet.		SMP VP-2482
	Baenidae indet.		SMP VP-2506
	Baenidae indet.		SMP VP-2513
	Baenidae indet.		SMP VP-3259
	<i>Hoplochelys</i>	sp.	SMP VP-1650
	<i>Hoplochelys</i>	sp.	SMP VP-2514
	Adocidae indet.		SMP VP-2663
	cf. <i>Plastomenus</i>	sp.	SMP VP-2517
	Trionychidae indet.		SMP VP-2447
	Trionychidae indet.		SMP VP-2452
	Trionychidae indet.		SMP VP-2515
	Trionychidae indet.		SMP VP-2664
	Trionychidae indet.		SMP VP-2665
	Trionychidae indet.		SMP VP-2667
	Trionychidae indet.		SMP VP-2668
	Trionychidae indet.		SMP VP-2669
	Trionychidae indet.		SMP VP-2694
	Trionychidae indet.		SMP VP-2697
	Trionychidae indet.		SMP VP-2810
	Testudines indet.		SMP VP-2518
	cf. <i>Brachychampsa</i>	sp.	SMP VP-2504

	Crocodylidae indet.		SMP VP-1321
	Crocodylidae indet.		SMP VP-2503
	Crocodylidae indet.		SMP VP-2511
	Crocodylidae indet.		SMP VP-2787
	Troodontidae indet.		SMP VP-3341
	Dromaeosauridae indet.		SMP VP-2505
	Theropoda indet.		SMP VP-2500
	Theropoda indet.		SMP VP-2709
	Theropoda indet.		SMP VP-2788
	Theropoda indet.		SMP VP-3357
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2507
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2696
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-3323
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1319
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-2661
	Ankylosauria indet.		SMP VP-2519
	Hadrosauridae indet.		SMP VP-1320
	Hadrosauridae indet.		SMP VP-2508
	Hadrosauridae indet.		SMP VP-2692
	Hadrosauridae indet.		SMP VP-2809
	Ceratopsidae indet.		SMP VP-2509
	Ceratopsidae indet.		SMP VP-2693
	Dinosauria indet.		SMP VP-2516
	Dinosauria indet.		SMP VP-2789
	Dinosauria indet.		SMP VP-2808
	Vertebrata indet.		SMP VP-2480
	Vertebrata indet.		SMP VP-2502
	Vertebrata indet.		SMP VP-2512
	Vertebrata indet.		SMP VP-2520
	Vertebrata indet.		SMP VP-2662
	Vertebrata indet.		SMP VP-2695
371			
	Tyrannosauridae indet.		SMP VP-1113
374			
	Hadrosauridae indet.		SMP VP-1247
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1243
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1245
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1246
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1719
	Dinosauria indet.		SMP VP-1244
375			
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1248
376b			
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1336
377			
	Adocidae indet.		SMP VP-1308
	Trionychidae indet.		SMP VP-1307
	Trionychidae indet.		SMP VP-1309
	Trionychidae indet.		SMP VP-1310
383			
	Tyrannosauridae indet.		SMP VP-1317
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1641
	Hadrosauridae indet.		SMP VP-2087
	Ceratopsidae indet.		SMP VP-1642
	Ceratopsidae indet.		SMP VP-2088
384b			
	<i>cf. Lepisosteus</i>	sp.	SMP VP-2782
	<i>Hoplochelys</i>	sp.	SMP VP-1571
	<i>Hoplochelys</i>	sp.	SMP VP-2109
	Adocidae indet.		SMP VP-2356
	Adocidae indet.		SMP VP-2785
	Trionychidae indet.		SMP VP-1572
	Trionychidae indet.		SMP VP-1713
	Trionychidae indet.		SMP VP-1988

	Trionychidae indet.		SMP VP-2260
	Trionychidae indet.		SMP VP-2433
	Trionychidae indet.		SMP VP-2436
	Trionychidae indet.		SMP VP-2666
	Trionychidae indet.		SMP VP-2672
	Trionychidae indet.		SMP VP-2673
	Trionychidae indet.		SMP VP-2674
	Trionychidae indet.		SMP VP-2783
	Trionychidae indet.		SMP VP-3260
	<i>Ojoraptorsaurus</i>	<i>boerei</i>	SMP VP-1458
	Theropoda indet.		SMP VP-1318
	Theropoda indet.		SMP VP-2434
	Theropoda indet.		SMP VP-2435
	Theropoda indet.		SMP VP-2781
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1625
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1626
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1622
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1821
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-2157
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-2786
	Ankylosauria indet.		SMP VP-1570
	Ankylosauria indet.		SMP VP-2355
	Hadrosauridae indet.		SMP VP-1624
	Ceratopsidae indet.		SMP VP-2107
	Ceratopsidae indet.		SMP VP-2262
	Dinosauria indet.		SMP VP-1820
	Dinosauria indet.		SMP VP-2106
	Dinosauria indet.		SMP VP-2108
	Dinosauria indet.		SMP VP-2261
388b			
	Ceratopsidae indet.		SMP VP-2047
389b			
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1850
392b			
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1715
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2097
	Lambeosaurinae indet.		SMP VP-1534
	Ceratopsidae indet.		SMP VP-1533
	Ceratopsidae indet.		SMP VP-1714
403b			
	cf. <i>Lepisosteus</i>	sp.	SMP VP-2068
	Tyrannosauridae indet.		SMP VP-1574
	Theropoda indet.		SMP VP-2069
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-2067
	Ankylosauria indet.		SMP VP-1573
	Lambeosaurinae indet.		SMP VP-2263
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1575
	Dinosauria indet.		SMP VP-2066
	Dinosauria indet.		SMP VP-2191
	Dinosauria indet.		SMP VP-2784
405			
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1640
410b			
	Adocidae indet.		SMP VP-2389
	Trionychidae indet.		SMP VP-1834
	Testudines indet.		SMP VP-2671
	Tyrannosauridae indet.		SMP VP-2352
	Dromaeosauridae indet.		SMP VP-2430
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1866
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2065
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2104
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-2026
	Ankylosauria indet.		SMP VP-1832

	Hadrosauridae indet.		SMP VP-1867
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1865
	Dinosauria indet.		SMP VP-1833
	Vertebrata indet.		SMP VP-2700
411			
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1872
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1873
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1874
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1875
414b			
	Crocodylidae indet.		SMP VP-1823
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1825
	<i>Glyptodontopelta</i>	<i>mimus</i>	SMP VP-1826
	Hadrosauridae indet.		SMP VP-2823
415b			
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-1864
	<i>Alamosaurus</i>	<i>sanjuanensis</i>	SMP VP-2043
	Ankylosauria indet.		SMP VP-1831
	Ankylosauria indet.		SMP VP-1863
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1828
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-1829
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-2013
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-2089
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-2090
	Ceratopsidae indet.		SMP VP-1830
420b			
	Crocodylidae indet.		SMP VP-2049
	Ankylosauria indet.		SMP VP-2048
	Hadrosauridae indet.		SMP VP-2050
422			
	<i>Ojoceratops</i>	<i>fowleri</i>	SMP VP-2076
424b			
	Tyrannosauridae indet.		SMP VP-2105