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VERTEBRATE BIOSTRATIGRAPHY OF THE EOCENE GALISTEO FORMATION, NORTH-CENTRAL NEW MEXICO

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INTRODUCTION

Prior to the initiation of the rifting that formed the Rio Grande trough, a broad inland basin existed in north-central New Mexico. During the early Tertiary, from 300 to 1,200 meters of fluvial sandstone, conglomerate, mudstone and freshwater limestone of what is now referred to as the Gal isteo Formation were deposited in this basin (Gorham and Ingersoll, this guidebook). The age assigned to these continental sediments has varied; structural and lithologic considerations have resulted in age determinations ranging from Cretaceous to Oligocene. However, new vertebrate biostratigraphic evidence presented here confirms age assignments initially determined by Stearns (1943) and Robinson (1957); the Galisteo Formation ranges in age from early to late Eocene. In this paper, we briefly review previous biostratigraphic work and add to it the preliminary results of our ongoing research on the Galisteo Formation. The following institutional abbreviations are used: AMNH = American Museum of Natural History, New York; MCZ = Museum of Comparative Zoology, Harvard University, Cambridge; UCMP = University of California Museum of Paleontology, Berkeley; UCOM = University of Colorado Museum, Boulder; UNM-GE = University of New Mexico, Department of Geology Eocene Galisteo Collection, Albuquerque.

PREVIOUS STUDIES

Kelley and Northrop (1975, p. 62-67) provided an excellent and detailed summary of previous studies of the Galisteo Formation. Here, we discuss previous opinions on the age of the Galisteo and mention some studies not covered by Kelley and Northrop.

Hayden (1869, p. 40) first recognized the "Gallisteo [sic] sand group" as a lithologic unit and regarded it as Tertiary in age. Almost half a century later, Lee and Knowlton (1917, p. 184-185) reviewed the varied opinions on the age of the Galisteo (Johnson (1902), for example, considered it Cretaceous) and concluded that "the Galisteo sandstone should be correlated with Tertiary formations farther west that are similar to it in character and stratigraphic position." They also reported the first identified fossil plants from the Galisteo: *Sabal? ungeri and Dryopteris?* sp.

In 1943, Stearns reported the first vertebrate fossils from the Galisteo from collections made by T. E. White and himself. These were all from the upper part of the Gal isteo and were taken to indicate a Duchesnean age, now considered to be late Eocene, but at that time considered by Stearns to be early Oligocene. Stearns (1943) also included a list of fossil wood taxa.

In the 1940's to 1960's, field parties led by Ted Galusha (AMNH), Donald Savage and Wann Langston (UCMP), Peter Robinson (UCOM) and Craig Wood (MCZ) made small collections of vertebrate fossils in the Galisteo. Robinson (1957) reported the presence of *Coryphodon* in the lower part of the Galisteo, indicating an early Eocene (Wasatchian) age for these strata. Galusha (1966) mentioned remains of titanotheres from a small Galisteo outcrop near San Ysidro, and Leopold and MacGintie (1972) reported palynomorphs from this same Galisteo outcrop.

Since 1977, J. W. Froehlich, several University of New Mexico students and the authors have been systematically collecting vertebrate fossils from the Galisteo. This work has involved relocation of old localities as well as the discovery of new ones, and is still in progress. In addition, a detailed stratigraphic and sedimentologic study of a major portion of the Galisteo Formation was completed recently by Gorham (1979) (also see Gorham and Ingersoll, this guidebook).

GENERAL OCCURRENCE OF FOSSILS

Fossils in the Galisteo Formation fall into the following categories:

(1) Reworked fossils—Brachiopods reworked from upper Paleozoic strata and pavement-tooth shark teeth reworked from the underlying Cretaceous Mesaverde Group are found in clasts in some Galisteo beds.

(2) Fossil plants—Petrified wood, usually highly silicified, is common in channel sandstones throughout the formation. Lignitic stringers and other horizons likely to yield well preserved fossil leaf impressions have not been located yet by us, although poorly preserved (i.e. without cuticle and/or highly carbonized) leaf impressions have been encountered. Horizons likely to yield palynomorphs are common throughout the Galisteo, but other than the study by Leopold and MacGintie (1972), no palynological work has been done.

(3) Fossil vertebrates—Remains of fossil vertebrates, mostly mammals, are rare in the Galisteo Formation. Only two localities worthy of quarrying or screen-washing have been discovered. Most vertebrate remains so far encountered are isolated teeth or fragments of bone that defy precise identification.

LOCAL FAUNAS

"The term 'local fauna' is used by vertebrate paleontologists to designate an assemblage from one locality, or from several

localities, which are [sic] demonstrably stratigraphically equivalent or nearly so. It is a group of fossils local in both time and space" (Taylor, 1960, p. 10).

We feel that the fossil assemblages from the Galisteo Formation are now large enough to warrant the designation of two separate local faunas. We follow Taylor in our definition of "local fauna" and agree with Tedford (1970, p. 679) that local faunas "are not bodies of rock characterized biologically, but associations of geologically contemporaneous species." Thus, local faunas are *not* formal biostratigraphic units in the sense used by the American Commission on Stratigraphic Nomenclature (1961). Nevertheless, we advocate and adhere to the following guidelines when naming new local faunas: (1) names of rock-stratigraphic units should not be used as eponyms of local faunas; (2) new local faunas should be characterized by as complete a list of included taxa as possible; (3) as precise geographic and stratigraphic provenance as possible should be presented; (4) correlation of the local fauna with respect to a recognized time scale (e.g., the North American land mammal "ages") should be attempted.

Cerrillos Local Fauna

In the Cerrillos Hills just northeast of the town of Cerrillos (fig. 1), the lower part of the Galisteo has produced a small assemblage of vertebrate fossils that are Wasatchian in age. We designate this assemblage the Cerrillos local fauna (hereafter "C.I.f."). The C.I.f. is found in an interval approximately 183 to 244 meters above the base of the Galisteo Formation (fig. 2), the most fossiliferous locality being one discovered and collected by us in the SU/4, sec. 16, T14N, R8E. The following annotated list contains presently known taxa from the C.I.f.:

Class Osteichthyes
Family Lepisosteidae—isolated gar scales.

Class Reptilia
Order Testudines—a dorsal vertebra and shell fragments, some with trionychid-like pitting and others unsculptured.

Class Mammaha
Order Pantodonta

Coryphodon sp.—The specimen reported by Robinson (1957) apparently has been lost, but we have collected tooth fragments that show the rugose and lineated enamel typical of this genus.

Order Condylarthra
Hyopsodus powellianus—This relatively large species of *Hyopsodus* is represented by a fragment of a right lower jaw containing M/1 and an incomplete M/2 (fig. 3a,b). Large size

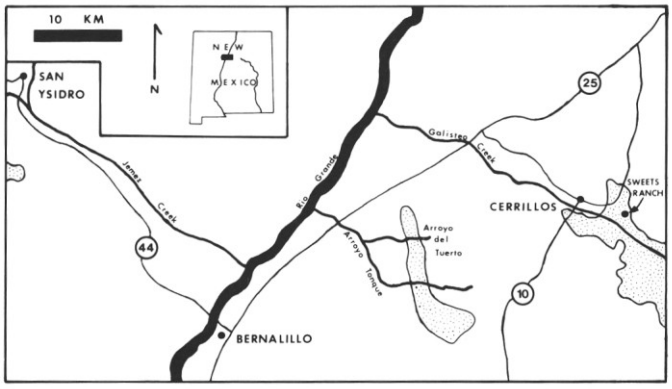

Figure 1. Index map of part of north-central New Mexico where major outcrops (stippled) of the Galisteo Formation are exposed.

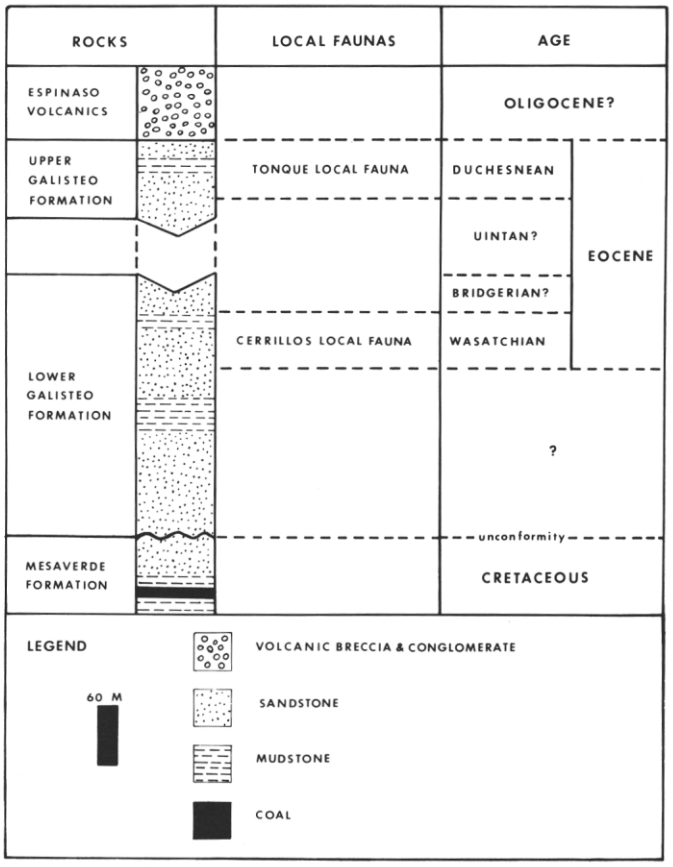

Figure 2. Rocks (lithology schematic), local faunas and their ages in the Arroyo Tonque-Cerrillos area of north-central New Mexico.

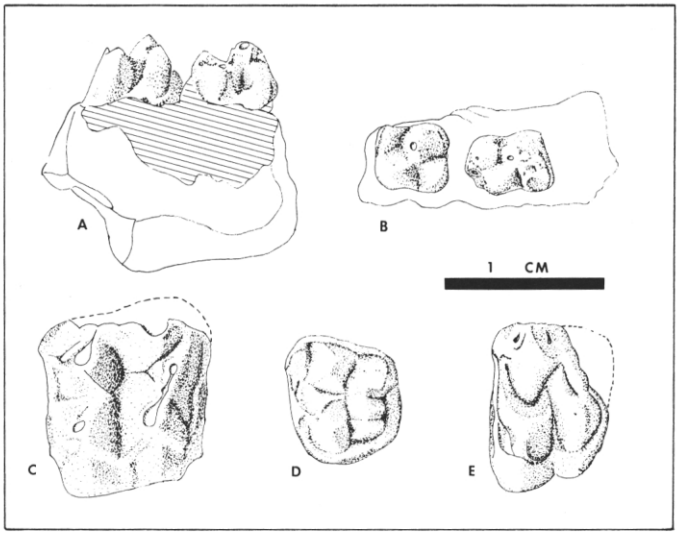

Figure 3. Fossil vertebrates from the Galisteo Formation. (A) and (B) Hyopsodus powellianus *(UNM-GE 078)—right lower jaw with M/1 and M/2 (broken), lateral view (A) and occlusal view (B). (C) cf.* Homogalax protapirinus *(UNM-GE 077)—right M1/ or M2/, occlusal view. (D)* Hyracotherium *sp. (UNM-GE 084)—left M3/, occlusal view. (E)* Poabromylus *sp. (MCZ 20269)—left M1/ or M2/, occlusal view.*

and resemblance to the type specimen (AMNH 4147) form the basis for referral to *H. powellianus* as defined by Gazin (1968).

Order Perissodactyla

cf. *Homogalax protapirinus*—*A* right M1/ or M2/ (fig. 3c) falls within the size range of *Homogalax protapirinus* as defined by Radinsky (1963). However, the lophs on this tooth are not as strong as in *Homogalax* specimens we have examined, and there is a small but distinct paraconule. A similar problem in referring teeth to *Homogalax* was discussed by McKenna (1960, p. 119-120).

Hyracotherium sp.—A small left M3/ (fig. 3d) is readily referrable to *Hyracotherium,* but a species-level identification of this isolated tooth is not justified.

The presence of *Coryphodon, Hyopsodus powellianus, Homogalax* and *Hyracotherium* indicates a Wasatchian age for the C.i.f. (Wood and others, 1941). To attempt a more precise correlation of the C.i.f. with either the Graybull, Lysite or Lostcabin "subages" of the Wasatchian is not possible until more representatives of this fauna are collected.

Tongue Local Fauna

Just north of Arroyo Tongue (fig. 1), one of its major tributaries, Arroyo del Tuerto, contains deposits of the upper part of the Galisteo Formation that are the most fossiliferous in the entire formation. These deposits contain a rich titanothere bonebed, discovered by Stearns (1943, fig. 7), as well as several lesser localities, all within the upper 61 meters of the formation. Stratigraphically equivalent deposits on Sweet's Ranch northeast of Cerrillos have produced comparable vertebrate remains. We designate the assemblage of vertebrate fossils from these two areas the Tongue local fauna (hereafter "T.I.f."; fig. 2). The T.I.f. contains the following taxa:

Class Reptilia

Order Testudines—unsculptured shell fragments.

Class Mammalia

Order Deltatheridia

Pterodon sp.—A badly broken right maxillary fragment with C-M2/ (fig. 4) is much smaller than *Hemipsalodon grad/is* (Me!lett, 1969), and we thus refer it to *Pterodon.* Because it is clear that the genus *Pterodon* is in need of revision (Savage, 1965), we refrain from attaching a specific name to this specimen.

Order Carnivora

Uintacyon sp.—Stearns (1943, p. 310) reported that T. E. White identified this genus from his collections made on Sweet's Ranch, but we have not yet been able to relocate the specimen his identification was based on and it may have been lost.

Order Perissodactyla

Teleodus uintensis—*Titanotheres* are the most abundant fossils in the T.I.f.; specimens (e.g. fig. 5) are housed in the AMNH, MCZ, UCMP, UCOM and UNM-GE collections. We thus far have examined the AMNH, MCZ and UNM-GE specimens; they are referrable readily to *Teleodus* and are closest in size and morphological details to *Teleodus uintensis* as described by Peterson (1931) and Scott (1945). However, it is possible that more than one species (or genus) of titanothere will be identified when all the Galisteo titanotheres are studied.

Forstercooperia sp.—A jaw fragment with DP/ 2-3 (fig. 6) belongs to a small unnamed species of *Forstercooperia* also represented in the AMNH collections by several specimens from the late Eocene I rdin Manha fauna of Asia. The Galisteo specimen is much smaller than *Forstercooperia grandis* of Radinsky (1967).

Order Artiodactyla

Poabromylus sp.—A broken left M1/ or M2/ (fig. 3e) possesses a strong internal cingulum, a feature characteristic of *Poabromylus.* In size and morphology, the Galisteo specimen falls within the range of variation of *Poabromylus kayi* (Wilson, 1974, p. 12-16), but we have refrained from assigning a specific name to a single tooth.

The T.I.f. is considered here to be Duchesnean in age. Although there is currently disagreement over the validity of the Duchesnean land mammal "age" (e.g., Wilson, 1978), we follow Tedford (1970) and Golz (1976) in retaining the Duchesnean as a late Eocene North American land mammal "age" characterized by the fauna of the Lapoint Member of the Duchesne River Formation in Utah (Andersen and Picard, 1972). The abundance of *Teleodus* in the T.I.f. and the presence of *Poabromylus* suggest that the T.I.f. is correlative with the Lapoint fauna, and thus Duchesnean in age (Andersen and Picard, 1972; Wood and others, 1941). In view of the paucity of taxa in the T.I.f., this correlation is still a tentative one, but even if further studies reveal that the T.I.f. is not a Lapoint equivalent, it is clearly a late Eocene fauna.

The titanothere remains mentioned by Galusha (1966), found in a small Galisteo outcrop between the Sierrita and Jemez faults near San Ysidro (fig. 1), may be a temporal equivalent of the T.I.f. However, it is not possible at present to demonstrate stratigraphic equivalence between this outcrop and those containing the T.I.f., and this has dissuaded us from including these titanotheres in the T.I.f. (although they are referrable to *Teleodus uintensis).* Further stratigraphic work and more diverse collections will be needed to decide whether these fossils properly belong in the T.I.f. or in a new local fauna. Nevertheless, we would like to emphasize that the outcrop discussed by Galusha (1966) is probably not San Jose

Figure 4. Pterodon *sp. (AMNH 96434) from the Tonque local fauna. Right maxillary fragment with C-M2/, lateral view above and occlusal view below. Bar is four cm long.*

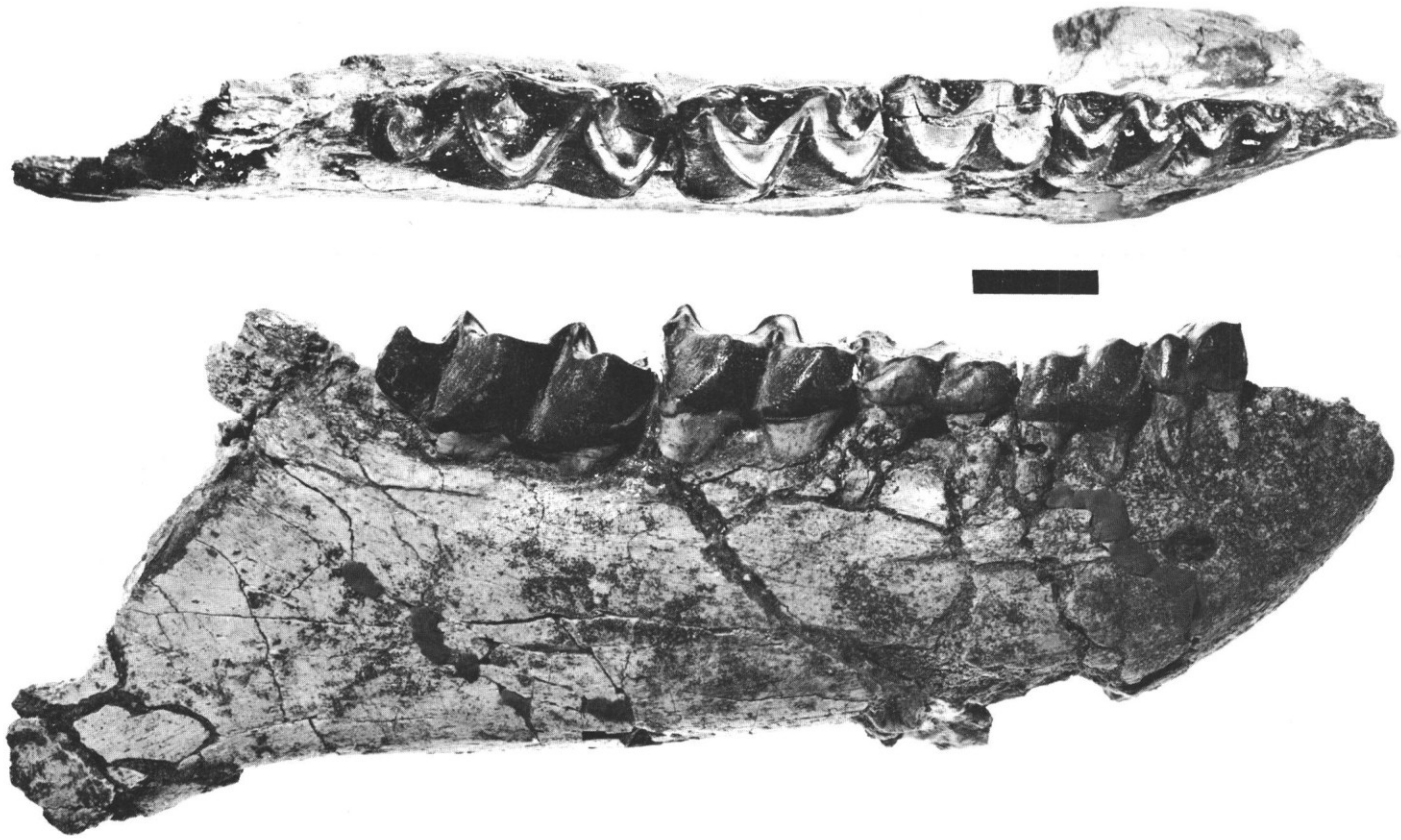

Figure 5. Teleodus uintensis *(UNM-GE 070) from the Tonque local fauna. Right lower jaw with P/3-M/3, occlusal view above and lateral view below. Bar is four cm long.*

Formation as some workers (e.g., Slack, 1973) have mapped it. The titanotheres suggest a Duchesnean age for this outcrop, which means it was deposited after the San Jose Formation, whose youngest strata are Wasatchian in age (e.g. Lucas, 1977). Moreover, the San Jose and Galisteo formations were deposited in separate basins on opposite sides of the Nacimiento uplift (Kelley and Northrop, 1975); the San Ysidro outcrop is temporally and geographically closer to Galisteo outcrops of known Duchesnean age.

The above discussion indicates that additional stratigraphic and paleontologic study of Galisteo exposures in north-central New Mexico would be worthwhile. Although vertebrate remains are rare in the Galisteo, much intensive prospecting certainly will add to the local faunas reported here, allow more detailed comparison of Galisteo faunas with temporally equivalent faunas elsewhere, and thus, will make possible a closer integration of Eocene tectonic, sedimentologic and paleontologic events in north-central and northwestern New Mexico.

CONCLUSIONS

Based on the above, the following conclusions can be made:

(1) Deposition of the Galisteo Formation spanned at least the entire Eocene.

(2) Although there is no fossil evidence that the lower part of the Galisteo is Paleocene or Cretaceous in age, the approximately 183 meters below the first occurrence of Wasatchian fossils may have been deposited before the beginning of the Eocene.

(3) The uppermost Galisteo is Duchesnean in age; there is no evidence for assigning an Oligocene age to any part of the Galisteo Formation.

(4) The Galisteo sediments (approximately 900 m thick) between the Wasatchian C.i.f. and the Duchesnean T.I.f. have failed so far to produce fossil remains by which their age can be assessed. Thus, it is not certain whether Gal isteo deposition was essentially continuous throughout the Eocene or whether major hiatuses exist between the lower and upper Eocene strata.

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Figure 6. Forstercooperia *sp. (AMNH 99662) from the Tonque local fauna. Left lower jaw with DP/ 2-3, occlusal view above, lateral view below. Bar is four cm long.*

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