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LOWER TERTIARY FORMATIONS AND VERTEBRATE FAUNAS OF THE SAN JUAN BASIN*

By George G. Simpson
American Museum of Natural History

History

The first geologist to examine the San Juan Basin was Newberry, who in 1859 with the Macomb expedition made a traverse from the San Juan River to San Pedro Mountain across the whole Paleocene-Eocene section, which he considered Cretaceous although recognizing that the upper part might be later. Early Tertiary fossils were first found by Cope on 7 September 1874, in the early Eocene beds of Arroyo Blanco. Cope made a good collection here and in the next main arroyo to the south, "Arroyo Almagre" of the maps. On this expedition Cope also saw the Paleocene beds near the present town of Cuba and named them "Puerco marls" but found no fossils. (None was found in this type area of the Puerco until 1949.) David Baldwin in 1880 found fossil mammals farther out in the basin in beds identified as equivalent to Cope's Puerco. He worked mainly in these beds until 1888 and obtained an excellent collection, described by Cope. The American Museum worked in the Paleocene in 1892 and 1896 (Wortman), in 1912-14 and 1916 (Granger) and in 1929 (Simpson). The beds have also been worked by the University of California (Camp), National Museum (Gazin), University of Kansas (R. Wilson), and several other institutions and have become classic American Paleocene. Several of the same parties, and some others more or less casually, also worked the early Eocene along the eastern edge of the basin but except for Granger in 1912, no really extensive collecting was done here until recently. In 1946 the American Museum (under Simpson) resumed intensive work in the San Juan Basin and has continued every summer since then, mainly in the Eocene but with some work in the Paleocene, as well. Strictly stratigraphic studies in the basin have been widespread and have involved many workers, but for the most part these have concentrated on pre-Tertiary rocks.

Nomenclature

The nomenclature of these formations has become seriously confused. The principal usages are included in the following summary:

Cope, 1875, 1877	Granger, 1914, 1917	Simpson, 1948 Rocks	Simpson, 1948 Faunas
Wasatch group	Largo beds	San Jose formation	Largo
	Almagre beds		Almagre
	Tiffany beds		Tiffany
Puerco Marls	Torrejon	Nacimiento formation	Torrejon
	Puerco		Puerco

Wortman and Matthew found that the "Puerco" fossils collected by Baldwin and described by Cope really represent two sharply distinct successive faunas. They restricted the name Puerco to the older fauna and the beds in which it occurs and proposed the name Torrejon for the younger fauna and beds. Up to now, however, no one has ever succeeded in designating or mapping a line between the two supposed formations. Facies differences occur, but they are either unmappable or do not correspond with the faunal differences. Gardner therefore proposed in 1910 to call the Puerco and Torrejon, together, the Nacimiento group. Another difficulty has arisen, because it was finally established in 1949 that the type Puerco of Cope, near Cuba, contains only the Torrejon fauna of later authors and not their Puerco fauna. Simpson therefore proposed to call the rock unit the Nacimiento formation, following Gardner, but to continue designation of the two faunas, not formations, as Puerco and Torrejon.

Granger's name Tiffany was applied to a fauna of late Paleocene age in rocks that have always been mapped with the early Eocene and have never been lithologically defined, although it is possible that this can be done in the future. The fauna is undoubtedly distinct and is always called Tiffany, but the beds in which it occurs are lumped in the "Wasatch" of almost all students. Granger's Almagre and Largo were proposed to replace "Wasatch" and correspond with the names, but it remains doubtful whether either the rocks or the faunas can be sharply subdivided over any considerable area in this manner. Simpson therefore proposed to continue the usual practice of combining Tiffany, Almagre, and Largo in one rock unit, and gave this the new name, San Jose formation, because by all usual criteria it is entirely distinct from the type Wasatch and should not be confused with the latter under the same name. (An earlier alternative proposal, to revive Newberry's and Holmes' name "Canyon Largo" for this formation was based on erroneous understanding of its original applications, which were not to the "Wasatch" of authors or to the San Jose.) (For references and details, see Simpson 1948.)

Sequence and Relationships of Formations

In the western, southern, and southeastern parts of the basin, the Cretaceous ends with the persistent and characteristic Ojo Alamo sandstone, on which the Nacimiento formation is disconformable. In the southwestern exposures, around Ojo Alamo and Kimbetoh, the Nacimiento includes both early (Puercan) and middle (Torrejonian) Paleocene. The time lapse at the Ojo Alamo - Nacimiento disconformity is here small, and little noteworthy change in physical condition is evident, as the Nacimiento

sediments closely resemble those of the Kirtland (beneath the Ojo Alamo sandstone). Eastward, from Escavada Wash to the vicinity of Cuba, only middle Paleocene fossils have been found in the Nacimiento, and it is probable that in the most easterly exposures the early Paleocene sediments are lacking and the corresponding time is represented by a hiatus at the disconformity. To the north and northeast, the late Cretaceous formations and the Nacimiento both probably grade into the Animas formation, a fluviatile mass of andesitic debris derived from volcanic centers to the north, in Colorado. If this is correct, the Cretaceous-Tertiary transition occurs within this formation, at an undetermined level. Dinosaurs have been found in middle and lower parts of the Animas in Colorado and turtles of probable Paleocene age in the uppermost Animas in eastern exposures near Dulce, N. M., just south of the Colorado border, but no mammals are yet known.

In the northern part of the basin, the San Jose is disconformable on the Animas, with little significant time lapse. The San Jose here ranges from late Paleocene (Tiffanian) to early Eocene (Wasatchian) in age. In its eastern, southeastern, and central exposures all known San Jose fossils are early Eocene. Along the eastern margin, at least, where mammals of Wasatchian age have been found within 50 feet of the well-marked base of the San Jose and Torrejonian mammals a short distance below that horizon, the late Paleocene seems to be represented only by a hiatus at the sharp San Jose-Nacimiento disconformity. Except for Quaternary (and possibly some latest Tertiary) unconsolidated pediment, terrace, and valley sediments, the San Jose is the youngest formation in the San Juan Basin.

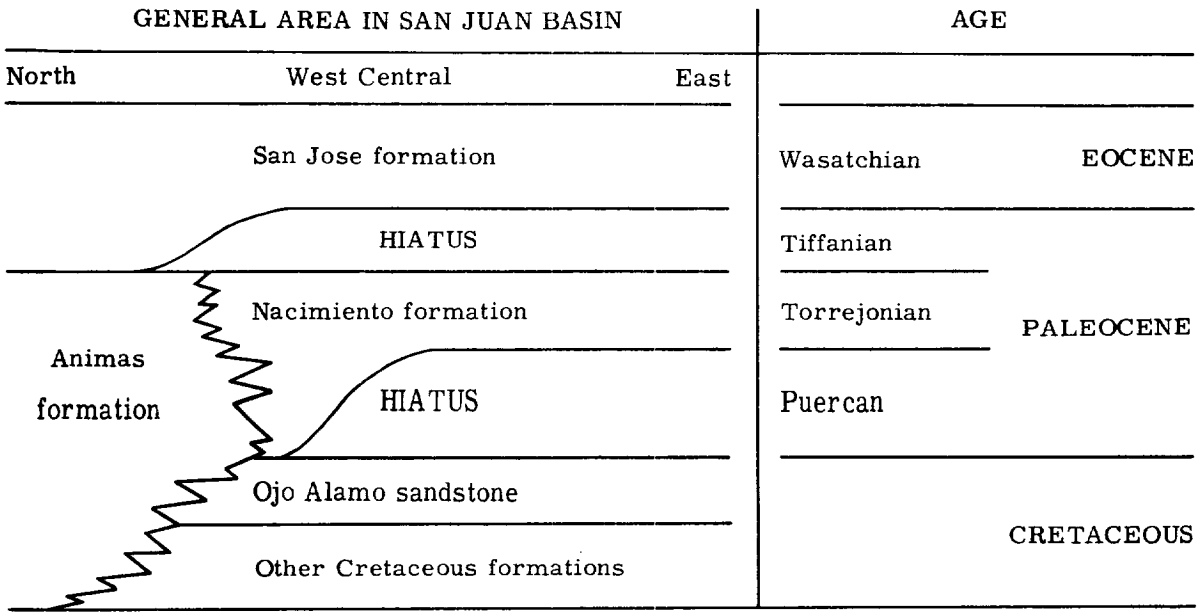
The entire sequence of sedimentary formations in the basin, from Pennsylvanian to Eocene, is essentially parallel. The several shifts of sedimentation between marine and terrestrial, and the existence of hiatuses at several points in the column suggest that angular unconformities must occur, but there was no definite pre-Eocene folding, as far as known, and any existing differences in dip are so slight that they have not been detected with certainty. Late uplift to the north and east have produced low regional dips away from these areas within the basin, and in the immediate mountain flanks the beds are steeply tilted; to vertical or even overturned (as on the scarp of the Nacimiento uplift and thrust fault on the western face of San Pedro mountain north of Cuba). The San Jose formation is involved in this tilting, and the major part of the deformation was therefore post-Wasatchian. There must, however, have been some regional uplift outside the immediate area of deposition, apparently east or northeast of the basin, between Torrejonian and Wasatchian time or during the latter, because easterly exposures of the lower part of the San Jose, here Wasatchian in age, include some coarse conglomerates and reworked marine Cretaceous fossils. This inferred movement may also account for the absence of late Paleocene in this region and for a possible, very small and not quite certain, angular unconformity of the San Jose on the Nacimiento.

The Paleocene

The Nacimiento Formation

The Nacimiento formation consists mainly of a series, about 400 to 800 feet in thickness, of banded, unctuous clays, usually in various shades of gray to yellowish, with an occasional red or wine-colored bed. Within these clays are numerous buff, gray, or white sandstone beds, occasionally persistent for several miles but more commonly occuring as local, strongly lenticular channels. The most definitive sediments are somber clays, pale gray to black, generally carbonaceous and often crowded with impressions of leaves and plant stems. A few thin and local seams of impure coal occur. Sediments like these also occur in the Cretaceous Fruitland and Kirtland formations, although the persistently intervening Ojo Alamo sandstone, usually prominently exposed, prevents stratigraphic confusion. No sediments like these somber clays occur in the San Jose formation. In some places, as around the head of Torrejon Arroyo and higher, central exposures in the Tertiary part of the basin, the upper Nacimiento is predominantly red-banded with little or no somber clay and here it does considerably resemble the San Jose. Such fossils as have been found in these beds are Torrejonian in age. Unfortunately, this difference in rock facies does not provide a basis for separation of Puercan and Torrejonian members or formations, because the Torrejonian fauna also occurs in somber-banded beds lithologically undistinguished from those containing the Puercan fauna.

The Nacimiento formation can be traced almost continuously, and usually with striking scarp or badlands exposures, from near the Colorado-New Mexico border in the Animas Valley, southward across the San Juan River, and then southeastward and eastward to the point of Cuba Mesa (type locality of Cope's "Puerco marls"), and finally northward to the upper Rio Puerco valley north of Cuba. (Ed. note: C. H. Dane (1946) has shown that strata termed Nacimiento in Rio Arriba and Sandoval Counties grade into Animas beds in San Juan County, N. Mex. and southern Colorado.) The most spectacular exposures are in the badlands of Kutz Canyon, south of Bloomfield. Throughout the area designated, Torrejonian fossils have been found, at least sparsely. Puercan fossils are known only from the middle part of this arc of exposures, the main localities being in Ojo Alamo Arroyo and Barrel Spring Arroyo (both branches of Coal Creek), Kimbetoh Arroyo, and Granger's "nameless arroyo",



(Not to scale vertically or horizontally)

DIAGRAM OF RELATIONSHIPS OF TERTIARY FORMATIONS IN THE SAN JUAN BASIN

	1 Puercan	2 Torrejonian	3 Tiffanian	4 Wasatchian
MULTITUBERCULATA				
Ptilodontidae	X	X	X	
Taeniolabididae	X	X		
MARSUPIALIA				
Didelphidae	X		X	
INSECTIVORA				
Deltatheridiidae	X			X
Palaeoryctidae		X		
Leptictidae		X	X	X
Nyctitheriidae				X
Pantolestidae		X		X
Mixodectidae		X		X
Apheliscidae				X
?CHIROPTERA				
?Phyllostomatidae			X	
PRIMATES				
Plesiadapidae			X	
Adapidae				X
Anaptomorphidae			X	X
Apatemyidae			X	X
TAENIODONTA				
Stylinodontidae	X	X		X

	1 Puercan	2 Torrejonian	3 Tiffanian	4 Wasatchian
RODENTIA				
Paramyidae	X			X
CARNIVORA				
Arctocyonidae	X	X	X	X
Mesonychidae		X	X	X
Oxyaenidae				X
Hyaenodontidae				X
Miacidae		X		X
CONDYLARTHRA				
Hyopsodontidae	X	X		X
Phenacodontidae		X	X	X
Periptychidae	X	X	X	
Meniscotheriidae				X
PANTODONTA				
Coryphodontidae				X
PERISSODACTYLA				
Carpolestidae			X	
TILLODONTIA				
Tillotheriidae				X
Equidae				X
ARTIODACTYLA				
Dichobunidae				X

GENERAL ASPECTS OF MAMMALIAN FAUNAS

sometimes called Bitonitsoseh, east of Kimbetoh. The classic Torrejonian localities, sources of most of the types of Cope (collected by Baldwin) and of Matthew (collected by Granger), are around the heads of the two last-mentioned arroyos and farther southeast in the upper parts of Escavada Wash and Alamito, Alamo, and Torrejon Arroyos. Recently R. W. Wilson has found a rich Torrejonian faunule in Kutz Canyon. Fossils from other areas are usually scattered and fragmentary, of more stratigraphic than paleontological interest.

Beyond the Rio Puerco north of Cuba, the Nacimiento formation continues but with very poor exposures (no fossils known) until it grades into the upper part of the Animas formation northward from Yegua Canyon. Similar gradation into the upper Animas may occur on the other side in and near the Animas Valley northeastward from near the Colorado border.

On the Nacimiento formation, see especially Sinclair and Granger, 1914; Granger, 1917; Reeside, 1924; Matthew, 1937; Dane, 1946.

The Eocene

The San Jose Formation

These sediments occupy a large, roughly oval area in the northeastern part of the San Juan Basin. They reach their greatest thickness, in excess of 2,000 feet, in the northern part of the basin, but a considerable, undefined part of this thickness is late Paleocene in age and perhaps can be - if possible, should be - separated as a distinct formation. This is the source of the Tiffany fauna. In general, exposures are poor in this region and few good Wasatchian mammals have been found. The best exposures and the source of the classical early Eocene fauna of the formation are in the southeast, especially along both sides of the continental divide from Yegua Canyon (above Llaves) and north of Gavilan Arroyo (more or less ten miles north of Lindrith) southward to about the latitude of La Jara. The formation in this region, all Wasatchian, reaches a maximum thickness of a little over 1,000 feet.

In this, its type region, the San Jose formation has three main lithological facies, sharply different in extreme development but intergrading and not, as yet, successfully used as map units. One facies, best seen in Yegua Canyon, consists of a succession of heavy, cross-bedded sandstone and conglomerate with relatively thin and variable clay and silt beds between them. The lowermost sandstone is fairly persistent and its lateral equivalents form a cap or rim rock above the Nacimiento around Cuba (to the point of Cuba Mesa) and well out into the basin, e.g., near Lybrook's and on Huerfano Mesa, along the conference route. Except for these basal sandstone beds, the Yegua Canyon facies grades rapidly laterally into facies in which some widespread heavy sandstone beds, buff to reddish or so-called copper-colored, still occur but in which clays and silts predominate. The Almagre of Granger is a facies well displayed in Blanco and "Almagre" (or Red Lake) Arroyos and around the divide near Regina. It is strikingly banded, mostly in pastel shades, with pale yellow usually the predominate tone but the colors highly varied and picturesque in detail, yellow, violet, red, bluish, etc. The Largo of Granger generally overlies the Almagre, when it occurs, but the two intergrade considerably both vertically and horizontally. Where the Largo facies is most distinctively developed, especially on the west side of the divide near the heads of Gavilan and Oso Arroyos and their tributaries, the clays and silts are red and form a striking contrast with the gray or white channel sands which are also numerous in the Almagre facies.

More detailed descriptions of the San Jose and references to most of the pertinent literature are given in Simpson, 1948.

Faunas

Extensive faunal lists, still nearly up to date, are conveniently available in the literature and need not be given here in detail. For the Puercan and Torrejonian faunas see Matthew, 1937; for the Tiffanian, Simpson, 1935; and for the Wasatchian, Van Houten, 1945. Large, still undescribed, recent collections from the Torrejonian and the Wasatchian will make additions to the lists and permit revision and clarification, without substantially altering the nature of the faunas. The general aspects of the mammalian faunas are indicated in the accompanying tabulation of known families:

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NOTES