

PRELIMINARY REPORT ON THE AMERICAN
CLARK FORK MAMMAL FAUNA, AND ITS CORRELATION
WITH SIMILAR FAUNAS IN EUROPE AND ASIA

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RÉSUMÉ

En se fondant sur des récoltes effectuées durant les deux derniers étés (1975, 1976), il apparaît que pour l'Amérique du Nord, le Clarkforkian constitue un étage mammalien valide et important. La comparaison de la faune de mammifères du Clarkforkian avec la succession de faunes de mammifères qui encadre la limite Paléocène-Eocène en Europe, conduit à la conclusion que cette faune est très proche de celle de Meudon du Sparnacien inférieur. Aussi le Clarkforkian est considéré comme l'étage mammalien de la base de l'Eocène inférieur en Amérique du Nord.

La répartition stratigraphique et géographique des Notoungulés, liées à l'histoire climatique de la période Paléocène-Eocène, font qu'il est probable que ces Notoungulés sont originaires d'Amérique Centrale ou d'Amérique du Sud. Ils ont atteint l'Amérique du Nord précocement dans le Clarkforkian, et ils ont atteint le continent asiatique doit durant le Clarkforkian soit le Wasatchian inférieur. L'âge des faunes de Mammifères de Mongolie de Gashato et de Naran Bulak doit donc être considéré comme Eocène inférieur plutôt que Paléocène supérieur.

ABSTRACT

On the basis of collections made during the past two summers (1975, 1976), the Clarkforkian appears to be a valid and important land mammal age in North America. Comparing the Clarkforkian mammal fauna to the sequence of mammal faunas spanning the Paleocene-Eocene boundary in Europe, the Clarkforkian fauna is most similar to the basal Sparnacian fauna from Meudon. Thus the Clarkforkian is regarded as the earliest Eocene land mammal age in North America.

The stratigraphic and geographic distribution of notoungulates, together with the climatic history of the Paleocene and Eocene, makes it probable that notoungulates originated in Central or South America, reached North America early in the Clarkforkian, and reached Asia in the Clarkforkian or early Wasatchian. The age of the Mongolian Gashato and Naran Bulak mammal faunas is thus regarded as early Eocene rather than late Paleocene.

MOTS-CLÉS : ÉOCÈNE INF. (CLARKFORKIEN), FAUNE MAMMIFÈRE, FAUNE SPÉCIFIQUE, CORRÉLATION, WYOMING.

KEY WORDS : LOWER EOCENE (CLARKFORKIAN), MAMMALIAN FAUNA, SPECIFIC FAUNA, CORRELATION, WYOMING.

* Museum of Paleontology - The University of Michigan, Ann Arbor, Michigan 48109, U.S.A.

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INTRODUCTION

The Clark Fork vertebrate fauna was first recognized and defined in the northern Bighorn Basin of Wyoming by W. J. Sinclair & W. Granger (1912) and W. Granger (1914). The Clark Fork fauna was originally thought to lack representatives of the modern mammalian orders Perissodactyla, Artiodactyla, Rodentia, and Primates, and to contain the archaic reptile *Champsosaurus*. On this basis, the Clarkforkian was considered to be Palaeocene rather than Eocene in age, although it was recognized that some typically Eocene genera were present. G. L. Jepsen (1930), G. G. Simpson (1937), and others added new taxa to the Clark Fork fauna, but more recently R. C. Wood (1967) has questioned whether or not a distinctive Clark Fork assemblage of mammals can be recognized at all. Because of this confusion in the published reports on the Clarkforkian mammal age, and because the Clarkforkian appeared potentially to document the evolutionary transition from

archaic Paleocene to more modern Eocene faunas, we recently began an intensive new program of detailed stratigraphic study and fossil collecting in the Sand Coulee area of the Clark Fork drainage basin. This work is still in progress, and the present report is a preliminary one, based on the first two seasons of field work.

Our work has shown clearly that there is an important and distinctive Clark Fork mammal fauna. In this paper we wish first of all to list the major elements of the Clark Fork fauna as we now understand it. Secondly, we shall discuss the correlation of this fauna with the European sequence of mammal faunas, which has a direct bearing on the geological age of the Clarkforkian. Finally, we wish to discuss briefly the possible implications of the Clark Fork fauna for dating Mongolian localities of the Gashato-Naran Bulak level.

CLARK FORK MAMMAL FAUNA

During the past two field seasons, University of Michigan expeditions have collected fossil mammals from more than 150 localities in the Sand Coulee area of the northern Bighorn Basin in Wyoming. The Sand Coulee area covers more than 100 square miles (250 km²), and much of this

area is fossiliferous and very well exposed. Approximately one-third of the localities discovered so far are in Clark Fork beds. Work to date has been concentrated on locating the boundary between the Clarkforkian and Wasatchian¹ as precisely as possible, and it is now possible to map

1. Gingerich (1975, 1976a) stated that the Clark Fork and « Sand Coulee » faunas might be the same, and reported *Pelycodus* from the Clarkforkian. This was based on a misunderstanding of labels on fossils in the Princeton University collection. Our recent field work suggests that the term « Sand Coulee » is best applied to a fauna that is

clearly at the base of the Wasatchian and not part of the Clarkforkian. Whether the term « Sand Coulee » will continue to be useful must await further study. Our investigations to date indicate that *Pelycodus* first appears in Wasatchian beds; they do not substantiate the occurrence of *Pelycodus* from the Clarkforkian.

a sandstone complex separating the two across most of the study area. This sandstone unit appears to be conformable with beds above and below it. In the next two years we will attempt to determine the Tiffanian-Clarkforkian boundary with equal precision.

The most commonly found mammals characteristic of the early Eocene in the Bighorn Basin are listed in Table 1. As the table shows, the Clark Fork fauna includes some genera that originated in the Tiffanian such as *Plesiadapis*, *Carpolestes*, *Phenacodus*, *Ectocion*, etc. A second group of genera are first known from beds of Clarkforkian age. This group includes the earliest rodents (*Paramys*, etc.), tillodonts (*Esthonyx*), miacine carnivores, oxyaonid creodonts (*Oxyaena*, etc.), and uinatheres (*Probathyopsis*). *Coryphodon* also first appears in the Clarkforkian. The earliest perissodactyls in North America (*Hyracotherium*) have been reported from the Clarkforkian (Morris, 1966; Jepsen and Woodburne, 1969 — see also Gingerich, 1976b, p. 51), although we have not yet found any additional Clarkforkian specimens and it seems clear that *Hyracotherium* did not become well established in the Bighorn Basin until the beginning of the Wasatchian. The genera *Hyracotherium*, *Diacodexis*, *Pelycodus*, *Hyopsodus*, and «*Sinopa*» appear together as a group and mark the beginning of the Wasatchian.

The Tiffanian faunas of the Bighorn Basin are relatively well known, as a result of Jepsen's work, although little of this has been published as yet. From the data of Table 1 it is clear that a

major immigration of new forms occurred during the early part of the Clarkforkian. A second major immigration of new genera occurred at the beginning of the Wasatchian. Thus the Clarkforkian is bounded above and below by major faunal changes. Stratigraphic sections measured along the south side of Polecat Bench show that the total thickness of beds containing a Clarkforkian fauna is approximately 700 m (2100 ft) in this area, of which the lower 400 m (1200 ft) is in the Polecat Bench Formation and the remaining 300 m (900 ft) is in the overlying red-banded Willwood Formation. Considering the marked faunal changes at the beginning and end of the Clarkforkian, and the thick section of strata including a Clarkforkian fauna, the importance of this North American mammal age can no longer be questioned. In addition to the type area described here, Clark Fork faunas are also known from Montana, western and southern Wyoming, Colorado, and perhaps Baja California and Texas (Gingerich, 1976b; Morris, 1966; Rose, 1977; Schiebout, 1974).

We should note that in addition to the assemblage of genera characteristic of the Clarkforkian, listed in Table 1, distinctive species of many genera are found in this interval. *Plesiadapis cookei* and *Plesiadapis dubius* (see Gingerich, 1976b), and *Carpolestes nigridentis* (see Rose, 1975) are among the most important species confined to the Clarkforkian, and systematic revision in progress will identify additional species limited to this interval.

PALEOCENE-EOCENE TRANSITION IN EUROPE

The marked change in mammal faunas going from the Paleocene to the Eocene was first documented in Europe, and this change is among the most compelling evidence for placing the Paleocene-Eocene boundary at the base of the Sparnacian in the Paris Basin (Russell, 1969; Pomerol, 1969). The Thanetian faunas of northern France (Cernay, Berru) are dominated by archaic multituberculate, primate, and condylarth genera, whereas the lower Sparnacian locality of Meudon includes the first representatives of a more modern fauna with rodents, perissodactyls, oxyaenid creodonts, and *Coryphodon*. Thus the basic difference between the Paleocene and Eocene mammal faunas of the Paris Basin (where the Paleocene-Eocene boundary is defined) is the appearance of

these four groups at the beginning of the Eocene. The same four groups appeared early in the Clarkforkian in North America (see Table 1), suggesting that the Clarkforkian is properly correlated with the European Sparnacian and considered to be Eocene rather than Paleocene in age².

2. It has been traditional to regard the Clarkforkian as latest Paleocene in age, largely because of the Paleocene aspect of many of its elements. Our study has revealed the presence, sometimes in considerable numbers, of taxa of Eocene aspect, previously unknown or uncommon in the Clarkforkian. In a paper prepared before this study, one of us (Rose, 1977) upheld a latest Paleocene age for the Clarkforkian, but the information now available and discussed herein suggests that an early Eocene age is more probable.

In addition, the large species *Plesiadapis cookei* from the North American Clarkforkian is very similar to *Plesiadapis russelli* from Meudon

(Gingerich, 1976b), further supporting the correlation of these two faunas.

CLIMATE, NOTOUNGULATES, AND ASIAN CORRELATIONS

The climatic history of North America offers a plausible explanation for the major mammal immigrations in the North American Clarkforkian and Wasatchian. During the middle Paleocene a « subtropical » climate prevailed, but the late Paleocene (Tiffanian) is characterized by a cooler « warm temperate » climate (Wolfe & Hopkins, 1967; Hickey, pers. comm.). In the early Eocene (Clarkforkian and Wasatchian) the climate became « subtropical » again. The result was an Eocene « coupure » in mammal faunas similar to Stehlin's « grande coupure » in the Oligocene. New mammalian genera immigrated into the area of the Bighorn Basin following the northward expansion of subtropical climates and vegetation. Thus the first wave of immigration into the Bighorn Basin area in the Clarkforkian may have been composed largely of genera that originated in Central America (Sloan, 1969; Gingerich, 1976b, p. 86). Warmer climates in the early Eocene would also have made high latitude land bridges in the north more accessible to mammals (McKenna, 1975), and some immigration into the Bighorn basin region in the early Eocene may have been a result of intercontinental migrations. If this general hypothesis is correct, it has some important implications for Eocene paleobiogeography and faunal correlations.

Among the most interesting fossils discovered in Clarkforkian sediments in the past two years are two new specimens of the notoungulate genus *Arctostylops* (Gingerich, Parris & Rose, in prep.). Two specimens were known previously, one from the « Graybullian » (from an unknown locality in the Sand Coulee area, Matthew, 1915), and the other from near the Tiffanian-Clarkforkian boundary in the Sand Coulee area (Jepsen & Woodburne, 1969). Notoungulates are known from the late Paleocene of South America and underwent a broad radiation there during the Tertiary. In addition, two described species of the notoungulate genus *Palaeostylops* from central Asia are known from relatively complete dentitions (Matthew & Granger, 1925; Matthew *et al.*, 1929 — see also Dashzeveg, 1968), and two species of a second Asian genus, *Sinostylops*, were recently

described by Y. Tang and D. Yan (1976).

Asian notoungulates are known from two faunas, Gashato and Naran Bulak, that are usually considered to be late Paleocene in age (Szalay & McKenna, 1971). Thus there has long been a question as to whether notoungulates originated in South America, North America, or Asia. The fact that the only notoungulate genus in North America appeared as part of the Clarkforkian immigration, with a new fauna thought to be of southern origin, suggests that South America or just possibly Central America was probably the center of origin of notoungulates. Migration of notoungulates from Asia to South America via North America during the Clarkforkian is unlikely because it would have involved migration in a predominantly southward direction opposite that postulated for the Clarkforkian fauna in general and, more importantly, opposite the direction of change in climatic and vegetational zones. A more likely hypothesis is that notoungulates originated in Central or South America, migrated into North America during the early part of the Clarkforkian, and subsequently reached central Asia across a Bering land bridge.

The age of the mammal faunas of Gashato and Naran Bulak is difficult to determine because most of the mammals in these faunas are endemic forms. F. S. Szalay & M. C. McKenna (1971) noted this and postulated a « latest Paleocene » age for the Gashato fauna. The apparent Central American origin of notoungulates, and the fact that they do not appear in North America before the Clarkforkian suggests that the Gashato and Naran Bulak notoungulate faunas are not older than the beginning of the North American Clarkforkian. Since Szalay & McKenna (1971) based their age assessment of the Gashato fauna largely on comparison with North American mammals found in the Clarkforkian, we are in basic agreement with their correlation. However, correlation of the Clark Fork fauna itself with basal Sparnacian faunas in Europe suggests that the faunas of Gashato and Naran Bulak are more likely to be early Eocene than late Paleocene in age.

TIFFANIAN

CLARKFORKIAN

WASATCHIAN

* <i>Plesiadapis</i> (large)	-----		
<i>Chiromyoides</i>	-----		
<i>Carpolestes</i>	-----?		
* <i>Phenacolemur</i>	-----		
<i>Ectocion</i>	-----		
<i>Phenacodus</i>	-----		
<i>Thryptacodon</i>	-----		
<i>Dissacus</i>	-----		
<i>Didymictis</i>	-----		
		<i>Aletodon</i>	-----
		<i>Arctostylops</i>	-----
		<i>Probathyopsis</i>	-----
		* <i>Rodentia</i>	-----
		<i>Plagiomene</i>	-----
		<i>Haplomylus</i>	-----
		<i>Apheliscus</i>	-----
		<i>Esthonyx</i>	-----
		Miacine carnivores	-----
		* <i>Oxyaena</i>	-----
		* <i>Coryphodon</i>	-----
		* <i>Hyracotherium</i> (?)	-----
			<i>Hyracotherium</i>

			<i>Diacodexis</i>

			<i>Pelycodus</i>

			<i>Hyopsodus</i>

			Hyaenodontidae

Tabl. 1 — Time of first appearance and stratigraphic range of mammals characteristic of the early Eocene in the Big Horn Basin, Wyoming, showing genera present in the latest Tiffanian, Clarkforkian, and earliest Wasatchian. Note two major immigrations, one at the beginning of the Clarkforkian and the other at the beginning of the Wasatchian. Genera preceded by asterisks are present in the early Sparnacian locality of Meudon and suggest a Sparnacian (early Eocene) age for the Clark Fork fauna.

Date de première apparition et répartition stratigraphique des mammifères caractéristiques de l'Eocène inférieur dans le Big Horn Basin, Wyoming. On met en évidence les genres présents à la fin du Tiffanien au Clarkforkien et au Wasatchien inférieur. On remarque deux immigrations majeures, l'une au début du Clarkforkien et l'autre au début du Wasatchien. Les noms de genre précédés d'une astérisque sont présents dans le gisement de Meudon du Sparnacien inférieur et indiquent un âge Sparnacien (Eocène inférieur) pour la faune de Clark Fork.

CONCLUSIONS

On the basis of collections made during the past two summers, the Clarkforkian appears to be a valid and important land mammal age in North America. Comparing the Clarkforkian mammal fauna to the sequence of mammal faunas spanning the Paleocene-Eocene boundary in Europe, the Clarkforkian fauna is most similar to the basal Sparnacian fauna from Meudon. Thus the Clarkforkian is regarded as the earliest Eocene land mammal age in North America.

The stratigraphic and geographic distribution of notoungulates, together with the climatic history of the Paleocene and Eocene, makes it probable that notoungulates originated in Central or South America, reached North America early in the Clarkforkian, and reached Asia in the Clarkforkian or early Wasatchian. The age of the Mongolian Gashato and Naran Bulak mammal faunas is thus regarded as early Eocene rather than late Paleocene.

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