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FOSSIL MAMMALS FROM THE NEOGENE STRATA IN THE SINDA BASIN, EASTERN ZAIRE

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ABSTRACT Since 1989, a geological and paleontological expedition has been carried out in the Zairean part of the Western Rift Valley. During two field seasons, more than 600 fossil remains were collected in the Sinda basin, Gaty, Haut-Zaire, mainly as surface finds. This fossil collection contains 52 mammalian fossils which comprise the following taxa; ?*Agriotherium*, four proboscidean groups such as *Prodeinotherium*, ?*Anancus*, *Mammuthus subplanifrons* and *Stegodon kaisensis*, two Rhinocerotidae, i.e., ?*Aceratherium* and *Brachypotherium*, ?*Sivatherium*, *Hippopotamus*, and a bovid. The Sinda fauna is composed of both Miocene and Pliocene mammals and suggest that the strata including the fossils are of late Miocene to early Pliocene in age. This fauna resembles that from the Nkondo formation which is located in the Ugandan side of the Western Rift Valley. The composition of the fauna from the Sinda area may indicate a different paleoenvironment (probably more humid) in this area from that in contemporary East Africa.

RESUME Depuis 1989, une expédition géologique et paléontologique est réalisée dans la partie zaïroise de la branche occidentale du Rift. Durant deux saisons, plus de 600 restes fossiles ont été collectés dans le bassin de Sinda, Gaty, haut-zaïre, principalement comme découvertes de surface. Cette collection fossile contient 52 mammifères fossiles qui comprennent les taxa suivant; ?*Agriotherium*, quatre groupes proboscidean tels que *Prodeinotherium*, ?*Anancus*, *Mammuthus subplanifrons* et *Stegodon kaisensis*, deux Rhinocerotidae par exemple, ?*Aceratherium* et *Brachypotherium*, ?*Sivatherium*, *Hippopotamus*, et un bovidé. La faune de Sinda est composée des mammifères du miocène et du pliocène et suggère que le strate inclus les fossiles sont de l'age du miocène supérieur au début pliocène. Cette faune ressemble celle de Nkondo formation qui est située dans la partie ougandaise du Rift Occidental. La composition de la faune de l'aire de Sinda devra indiqué un paléoenvironement différent (probablement plus humide) dans cette aire de celui en l'est-aficain contemporain.

Key Words: Fossil mammals; Neogene; Western Rift Valley; Paleoenvironment; Eastern Zaire.

INTRODUCTION

Paleontological studies of the Western Rift Valley have been overshadowed by the dramatic discoveries of hominid and hominoid fossils from the Eastern Rift. However, the Western Rift is an ideal region for studying human evolution, assuming that the Mio-Pliocene hominoids evolved under the influence of the prosperity of the forest where they lived.

Historically, several fossil deposits have been known on both escarpments of the Western Rift. In the Ugandan part, the first report of fossils from the eastern coast of Lake Mobutu (= L. Albert) was made by Hopwood (1926), which followed the studies of Hopwood (1939) and Cooke and Coryndon (1970). Recently, Pickford et al. (1988, 1989, 1990) have reinvestigated this area. According to them, the problems of the localities and biostratigraphic context in the old works have been resolved. The "Kaiso formation", which was originally considered to be of Plio-Pleistocene age, seems to contain upper Miocene sediments (Pickford et al., 1988). It is also suggested that the mammalian fauna from the "Kaiso formation" include animals that preferred a humid environment.

In the Zairean part, on the other hand, Fuchs (1934) identified the fossil beds along the northern shore of Lake Rutanzige (= L. Edward) for the first time. Thereafter, Lepersonne (1949) and Hopwood and Lepersonne (1953) found several outcrops of Miocene fossil beds along the upper reach of the Semliki River. Hooijer (1963) described the Miocene fossil mammals collected so far from the former Belgian Congo, mostly from the Western Rift. Since 1982, Boaz and his colleagues have made an expedition to the basin of the Semliki River (Boaz, 1990). They successfully obtained many specimens in the upper Semliki region. Based on many fossil woods, they pointed out the existence of a dense forest in the upper Pliocene. The Zairean Plio-Pleistocene fossil beds have been previously regarded as the "Kaiso formation". However, de Heinzelin and Verniers (1987) renamed them the Lusso Beds because of the paucity of positive evidence indicating the similarity between the Ugandan and Zairean Plio-Pleistocene sediments.

Despite the recent investigations on the Plio-Pleistocene, Miocene sediments in Zaire have never been reinvestigated since Hooijer's study (1963). In 1982 and 1985, Boaz's team searched for fossil bed outcrops in the Sinda-Mohari area but failed to establish a site (Boaz, 1990).

We made two field surveys in the Sinda-Mohari area, Haut-Zaire during 1989 to 1990 and found many fossiliferous localities. This area was surveyed by Lepersonne in 1949 and by de Heinzelin in 1954, '57, and '60, and the collected fossil mammals were studied by Hooijer (1963). He considered the mammalian fauna from the Sinda-Mohari area as lower Miocene in age.

The majority of the fossil remains in our expedition were collected as surface finds. Most of them were fishes and aquatic reptiles. Mammalian remains were quite small in number (52 of 579 registered fossils). Since most of the fossils were fragmentary, identifiable specimens were restricted to a small portion of the collection. In the present report we describe the mammalian specimens from the Sinda basin and discuss the geological age of this fauna and the paleoenvironment in this area.

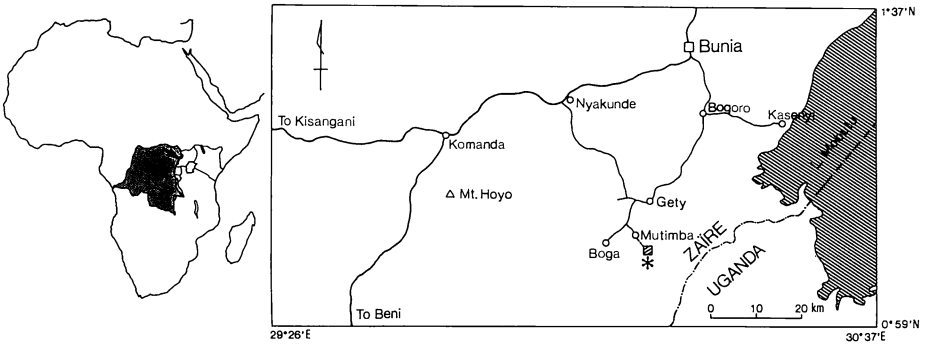

Fig. 1. Location of the surveyed area (hatched square).

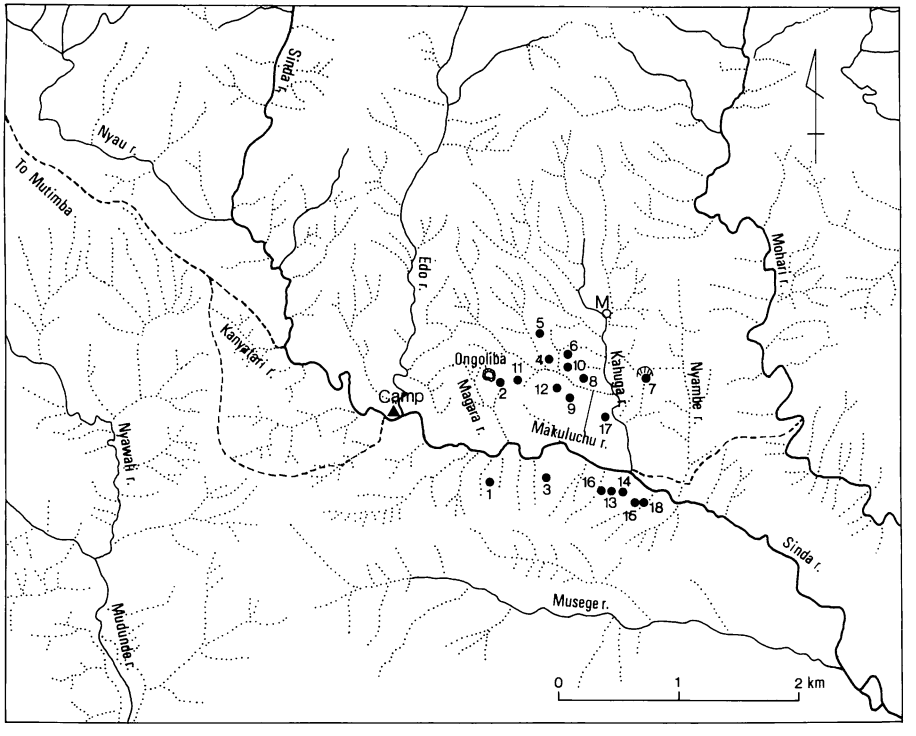

Fig. 2. Map of fossiliferous localities in the Sinda area. "M" denotes the molluscan site.

Table 1. Distribution of the fossil mammals from the Sinda area.

taxon \ site	1	2	3	4	5	7	8	9	10	11	12	13	14	15	17	18
?*Agriotherium* sp.														×		
Prodeinotherium sp.													×	×		
Anancus sp.												×		×		
Mammuthus subplanifrons													×			
Stegodon kaisensis													×			
unidentified Proboscidea			×			×					×		×	×		
?*Aceratherium* sp.											×					
Brachyotherium sp.			×													
unidentified Rhinocerotidae	×												×			
Hippopotamus cf. *imagunculus*	×															
?*Sivatherium* sp.											×					
Bovidae							×									
unidentified mammals	×			×	×			×		×	×		×	×		×

LOCALITIES

Surveys were carried out in the basins of the Sinda and Mohari Rivers which are located on the western escarpment of the Western Rift Valley, ca. 70 km south-south-east of Bunia, Haut-Zaire (Fig. 1). Eighteen vertebrate fossiliferous sites were established on both banks of the Sinda River (Fig. 2), while no exposed fossil beds were found in the basin of the Mohari River. These localities are almost correspond to those of de Heinzelin (Hooijer, 1963). The fossil compositions of mammals at each locality are shown in Table 1. The fossil remains seemed to occur in the upper, middle, and the upper part of the lower members of the Sinda Beds (Makinouchi et al., this volume).

SYSTEMATICS

Class Mammalia
Order Carnivora
Family Ursidae Gray, 1825
Genus ?*Agriotherium* Hendey, 1972

Material: SN-228
Locality and horizon: site-15, upper member of the Sinda Beds

Description. This tooth fragment has been identified as a carnivora upper molar (Plate 4, Fig. 17). This is not worn but has been eroded, so that the detailed characteristics of the crown are not observable. The enamel thickness on the occlusal surface is 0.6 mm. Despite the insufficient diagnostic characters, we tentatively allocate it to *Agriotherium* by comparison with the materials of the National Museum of Natural History, Paris.

Order Proboscidea
Family Deinotheriidae Bonaparte, 1845
Genus *Prodeinotherium* Ehik, 1930
Prodeinotherium sp.

Materials: SN-273, 500
Localities and horizon: site-14, 15, upper member of the Sinda Beds

Description. An isolated right upper third premolar (SN-500) (Plate 1, Fig. 3a,b) and a right lower second molar fragment (SN-273) (Plate 1, Fig. 4a,b) are identified as this taxon. In the occlusal aspect of the former, paracone and metacone are continuous with each other, while protocone and hypocone are delimited by a deep and sharp sulcus. The buccal two cusps and protocone have been worn, exposing the dentine core. Enamel thickness measured on the worn surface is ca. 3 mm. From the paracone, a well-developed parastyle runs mesiolingually, coming into contact with the cingulum of the mesiolingual margin of the tooth which reaches the distal margin of the protocone. Likewise, a well-developed short metastyle from the metacone runs distally and connects with the weak cingulum of the distal margin. Mesostyle is not present. The mesial surface of the tooth is somewhat angulated, while the distal surface is rather flattened. Mesiodistal and buccolingual lengths are 48 mm and 44 mm, respectively, and their ratio is 1.09. This upper premolar is small compared with that of *Prodeinotherium* and *Deinotherium* reported so far. The length/width ratio is almost at the midpoint between those of *Prodeinotherium* (1.04) and *Deinotherium* (1.15) (Harris, 1978).

The lower second molar is preserved in the hypolophid and posterior cingulum, showing the prominent hypoconid and the broken apex of the entoconid. From the hypolophid, weak mesiobuccal and mesiolingual ridges extend mesially. The posterior cingulum is almost straight, measuring 10.2 mm in thickness and 33 mm in buccolingual width. On the distal surface of the hypolophid, a flat wear facet is observed. This facet does not reach the dentine. The enamel thickness at the broken edge of the median valley is 2 mm. The crown height at the tip of the hypoconid is 33 mm and the width of the hypolophid is 50.7 mm. The width of this molar is rather small compared with the smallest width (63 mm) of *Deinotherium* and falls within the range of *Prodeinotherium* dimension (48-59 mm) (Harris, 1973). Since the morphology of these teeth is not contradictory to that of *Prodeinotherium*, we allocate them to this taxon according to Harris (1973).

Family Gomphotheriidae Hay, 1922
Genus ?*Anancus* Aymard, 1885

Materials: SN-262, 501
Localities and horizon: site-13, 15, upper member of the Sinda Beds

Description. A molar fragment (SN-262) (Plate 2, Fig. 5a,b) and a fragmentary

bunodontic cusp (SN-501) (Plate 2, Fig. 6) belong to this taxon. The molar fragment preserves the marginal cones at a corner showing incompletely a trifoliated wear figure. A preserved groove between the cones is invested in cementum, at which the cingulum is well developed basally. The enamel on the worn surface is 5.8 mm thick. SN-501 is not worn and the enamel is 8 mm thick at the apex. On the enamel surface of these tooth fragments, fine horizontal striates are observed.

Gomphotheriidae comprise many genera. The present materials are insufficient to obtain diagnostic features for identification at generic level. However, *Anancus* seems to be closest to these specimens because of the round and bunodontic shape of the cusps and the presence of cement in the groove between cones.

Family Stegodontidae Osborn, 1918
Genus *Stegodon* Falconer, 1857
Stegodon kaisensis Hopwood, 1939

Material: SN-256
Locality and horizon: site-14, upper member of the Sinda Beds

Description. This specimen is a small piece of a molar (Plate 2, Fig. 7). It is characterized by a brachyodontic lophodont and a wrinkle pattern on the enamel surface. The thickness of the enamel is 4.5 mm. These characteristics indicate that this specimen belongs to *S. kaisensis*. This species was originally reported from Kaiso, Uganda, on the opposite side of the Western Rift (Hopwood, 1939).

Family Elephantidae Gray, 1821
Genus *Mammuthus* Burnett, 1830
Mammuthus subplanifrons Osborn, 1928

Materials: SN-247, 282
Locality and horizon: site-14, upper member of the Sinda Beds

Description. SN-247 is a fragment of a half ridge with a posterior isolated column (Plate 2, Fig. 8a,b). A cone-pair tightly converges at the summit. The crown height is 47 mm and the basal width of the ridge is 25.7 mm. The broken medial surface indicates the absence of a median cleft. On the distal surface of the lateral cone, three vertical ridges are observed. The enamel is rather thick. SN-282 is a cone fragment whose shape resembles that of SN-247. These specimens show advanced characters compared with the cheek teeth of gomphotheres. The cone shape of these specimens is similar to that of *Stegotetrabelodon* and *Mammuthus subplanifrons*. However, the absence of the median cleft indicates a closer affinity to the latter taxon.

Unidentified Proboscidea

Materials: SN-118, 121, 226, 232, 248, 255, 257, 274, 275, 286, 310, 330A, B, C
Localities and Horizons: site-7, middle member, site-12, upper part of lower member, site-14, 15, upper member of the Sinda Beds

Description. SN-330A,B,C consist of three pieces of enamel fragments and an apical tip probably originating from a tusk (Plate 4, Fig. 13). The enamel is thick, and in the vicinity of the tip several grooves on the enamel emboss ridges which extend axially. The enamel has been worn at the tip. This specimen seems likely a deciduous incisor.

The other specimens are small fragments of enamel or teeth. Although they seem to be composed of several taxa, further identification is impossible because of the lack of diagnostic characters.

Order Perissodactyla
Family Rhinocerotidae Owen, 1845
Genus *Brachypotherium* Roger, 1904
Brachypotherium sp.

Material: SN-313
Locality and horizon: site-3, middle member of the Sinda Beds

Description. A left talus, which preserves the medial half of the trochlea, posterior calcaneal, scaphoidal, and a part of the cuboidal facets, has been identified as this taxon (Plate 3, Fig. 12a, b). The anteroposterior diameter at the medial margin of the trochlea is 59 mm, and the maximum height of the medial half is 62 mm. The scaphoidal facet is concaved and measures 50 mm in width and 40 mm in height. Extrapolations of these measurements agree with those of *Brachypotherium* (Hooijer, 1963).

Unidentified Rhinocerotidae

Materials: SN-284, 300, 557
Localities and horizons: site-1, middle member, site-12, upper part of lower member, and site-14, upper member of the Sinda Beds

Description. Among these specimens, only SN-300 retains diagnostic features (Plate 3, Fig. 9a,b). It is a paracone portion of a left upper cheek tooth. The occlusal surface is worn and the crown height is 47 mm. The paracone style is well-developed. It becomes weaken and disappears basally. The ectoloph apparently extends straight. Enamel thickness on the occlusal surface is 2.6 mm. On the enamel surface, weak horizontal striates are observed. It is difficult to identify this specimen with certainty. However, its hypsodontic character and the markedly constricted paracone may indicate close affinity to *Aceratherium* (Hooijer, 1963, 1978).

The other enamel and tooth fragments show rhinocerus characters. The enamel

thickness is 1.8 mm in SN-284 (Plate 3, Fig. 10) and 2.5 mm in SN-557. The badly broken state of these specimens defies further identification.

Order Artiodactyla
Family Hippopotamidae Gray, 1821
Genus *Hippopotamus* Linnaeus, 1758
Hippopotamus cf. *imagunculus* Hopwood, 1939

Material: SN-087
Locality and horizon: site-1, middle member of the Sinda Beds

Description. A lower canine fragment is tentatively identified as *Hippopotamus imagunculus* (Plate 4, Fig. 14a,b). There are many axial striates on the enamel surface. Enamel thickness is less than 1 mm. The sectional outline shows a semicircular shape whose mesiodistal diameter is 17.5 mm. This diameter is quite small, compared with that of other hippopotamids from East Africa stored at the National Museum of Kenya. This specimen seems likely to be a part of the slender tip of the right lower canine and seems to come from a small hippopotamid species such as *H. imagunculus*. This species has been reported from the Ugandan part of the Western Rift Valley (Cooke & Coryndon, 1970; Pickford, 1990).

Family Giraffidae Gray, 1821
Genus ?*Sivatherium* Falconer et Cautley, 1832

Material: SN-302
Locality and horizon: site-12, upper part of lower member of the Sinda Beds

Description. An unworn buccal enamel fragment of an upper cheek tooth is tentatively identified as this taxon (Plate 4, Fig. 16). The buccal style is well developed, and the crown height is 41 mm.

Family Bovidae Gray, 1821
Gen. et sp. indet.

Material: SN-522
Locality and horizon: site-8, upper part of lower member of the Sinda Beds

Description. A right upper first or second molar is identified as this taxon (Plate 4, Fig. 15a,b,c). This molar is brachyodontic and the lingual surface of the crown is strongly slanted. Both mesiodistal and buccolingual lengths are 18 mm. The distal half is rather compressed buccolingually (15 mm) compared with the mesial one (18 mm). The occlusal surface has been worn, exposing the dentine core. The parastyle and mesostyle are well developed, while the metastyle is moderately developed. Between the protocone

and metaconule, a small intact tubercle is seen. The outline of the central cavities is simple. Although this tooth is one of the well-preserved materials in our collection, it is difficult to identify further.

Unidentified Mammalia

Material: SN-276
Locality and horizon: site-14, upper member of the Sinda Beds

Description. A hip bone fragment preserving the acetabulum and the basal part of the ilium is undetermined (Plate 3, Fig. 11). The diameter of the acetabulum is ca. 37 mm. There is a large foramen at the bottom of the acetabulum. The lunar surface is not developed.

DISCUSSION

Most of the fossil remains from the Sinda basin are fishes and aquatic reptiles. Fossil mammals are quite rare and fragmentary. Badly broken fossils are also seen in Hooijer's report of the Sinda-Mohari areas (1963). The fossils from the Sinda basin and adjacent area seem to be preserved worse than those from the Ugandan side of the Western Rift Valley (Senut & Pickford, 1988). It has been said that the activation of rift valley results in the asymmetric uplift of the shoulders on both sides in general (Pickford, 1986). In fact, the Monts Bleus on the Zairean side is more than 600 m higher than the Itwara Hills on the Ugandan side around Lake Mobutu. The broken fossils from the Sinda basin may indicate that they were brought through steeper streams into large rivers or lake(s).

Among the fossil mammals from the Sinda basin, four proboscideans have been

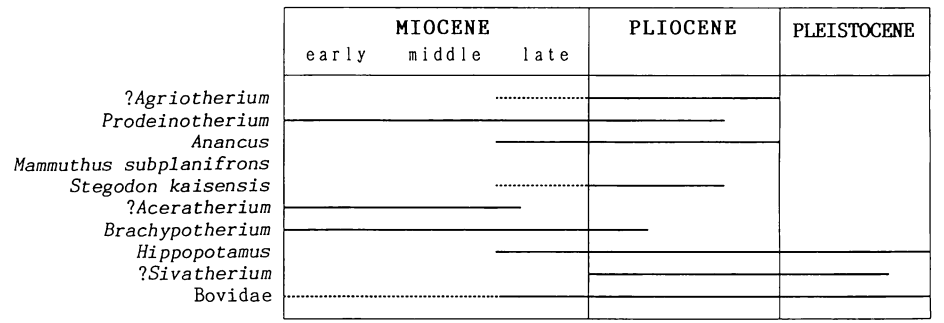

Fig. 18. Chronological distribution of the Sinda fossil mammals.

identified with certainty. They are Mio-Pliocene animals consisted of small-sized *Prodeinotherium*, *Anancus*, *Stegodon kaisensis,* and *Mammuthus subplanifrons* (Fig. 18). In the small collection of mammals, the existence of the four proboscideans suggests the diversity of this animal in this area (Pickford et al., 1988). The deinotherian teeth from the Sinda basin are characterized by their small size and fall within the range of *Prodeinotherium*, comparable to the small-sized *Prodeinotherium* from East African lower Miocene deposits (MacInnes, 1942). Hooijer (1963) reported a second upper molar fragment of *Prodeinotherium* (he identified it as *Deinotherium* (= *Prodeinotherium*) *hobleyi*) from the almost identical locality in the Sinda basin and also noted its small size. African *Prodeinotherium* have been reported from many localities, and they show a tendency to increase in size through time (Harris, 1987). It is unlikely, however, that the existence of the small-sized *Prodeinotherium* means that the Sinda deposits are contemporary to those of East Africa, because other associated proboscideans show advanced characters and are not of early to middle Miocene animals. Rather, the existence of the small-sized *Prodeinotherium* may suggest that this animal was living in a different paleoenvironment from that in East Africa.

The fossils other than Proboscidea have been tentatively identified as a small-sized *Hippopotamus* (probably *H. imagunculus*), two Miocene Rhinocerotidae, *Brachypotherium* and ?*Aceratherium*, a Giraffidae (?*Sivatherium*), and a Bovidae. These mammals belong to the late Miocene-Pliocene fauna as well (Fig. 18). Hooijer (1963) gave lower Miocene age to the Sinda-Mohari fauna. However, a biostratigraphic comparison with well-studied East African faunas could reject this possibility. Hipparion is one of the key fossils of late Miocene to Pliocene age in Africa. We have not yet obtained a fossil of this animal so far, while Senut and Pickford (1988) have found the fossils on the Ugandan side of the Western Rift. It is not clear whether lack of hipparion fossils in our collection indicates the absence of this animal in the Zairean part of the Western Rift or is simply a chance result.

A deposit contemporary to the Sinda basin has been reported from the Nkondo area on the Ugandan side of the Western Rift (Pickford et al., 1988). Regarding the composition of the fauna and paleobotanical evidence, Pickford (1990) speculates that the late Mio-Pliocene environment in the Western Rift was rather humid (tropical rain forest to tropical seasonal forest-savanna mosaic) compared with that of East African contemporary. The mammalian fauna from the Sinda basin consist of the animals that lived in the environments ranging from the tropical rain forest to tropical seasonal forest-savanna mosaic (Pickford, 1990), except for Giraffidae. This presents the further evidence that the environment of the Western Rift in late Miocene to Pliocene was humid.

The Sinda basin and the adjacent areas in Zaire present us an opportunity to investigate rare fossil sites which contain animals that lived in a humid environment. Furthermore, their geological age is late Miocene to Pliocene, which is the most important age for studying the evolution of hominoids and hominids.

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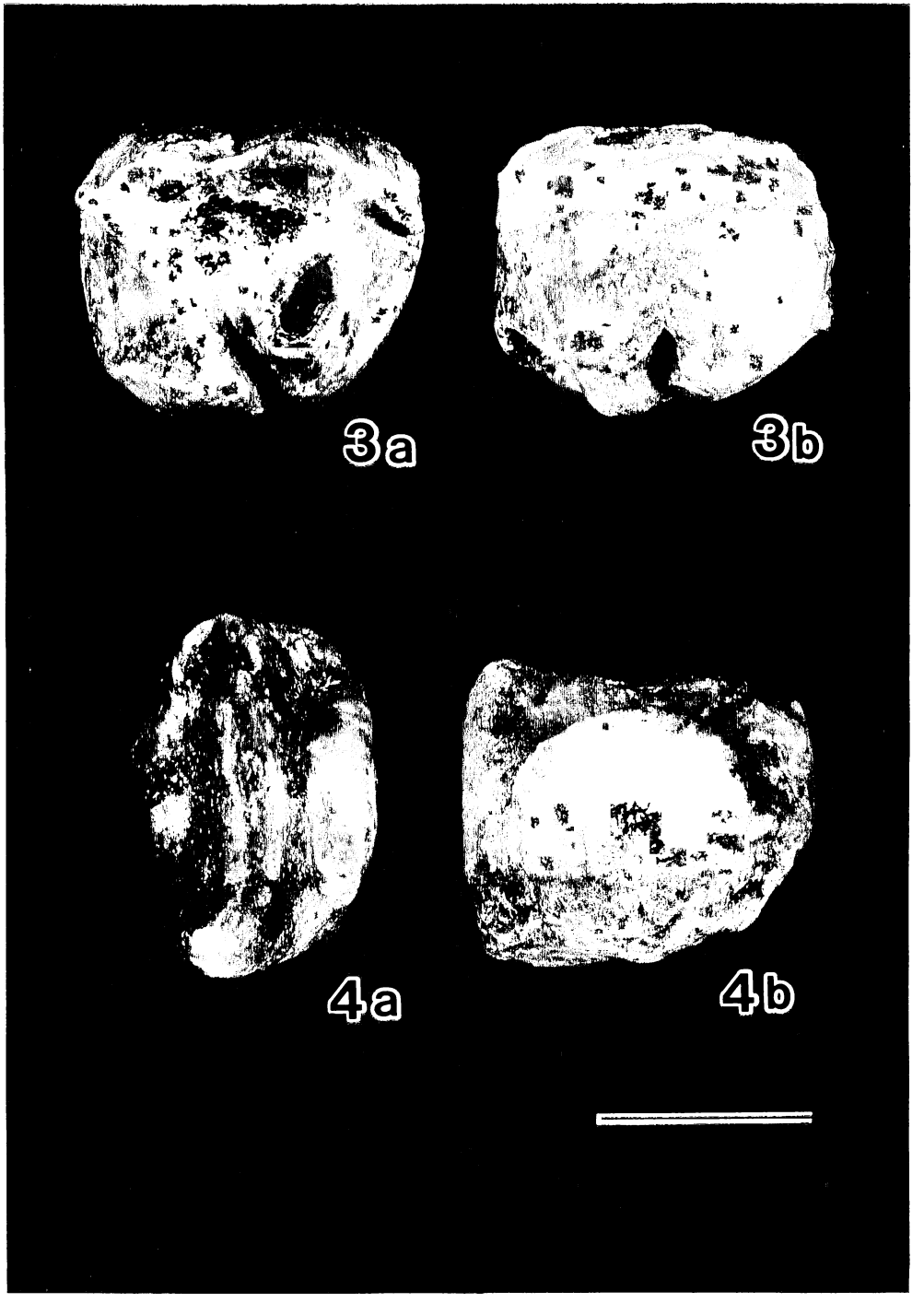
Explanation of Plate 1.

Prodeinotherium sp. (scale bar 3 cm)

Fig. 3a,b. Occlusal (a) and buccal (b) views of the right upper third premolar (SN-500).

Fig. 4a,b. Occlusal (a) and distal (b) views of the distal half of the right lower second molar (SN-273).

Plate 1



Explanation of Plate 2.

Anancus sp. (scale bar 3 cm)

Fig. 5a,b. Occlusal (a) and lateral (b) views of a molar fragment (SN-262).

Fig. 6. Lateral view of a cone fragment (SN-501).

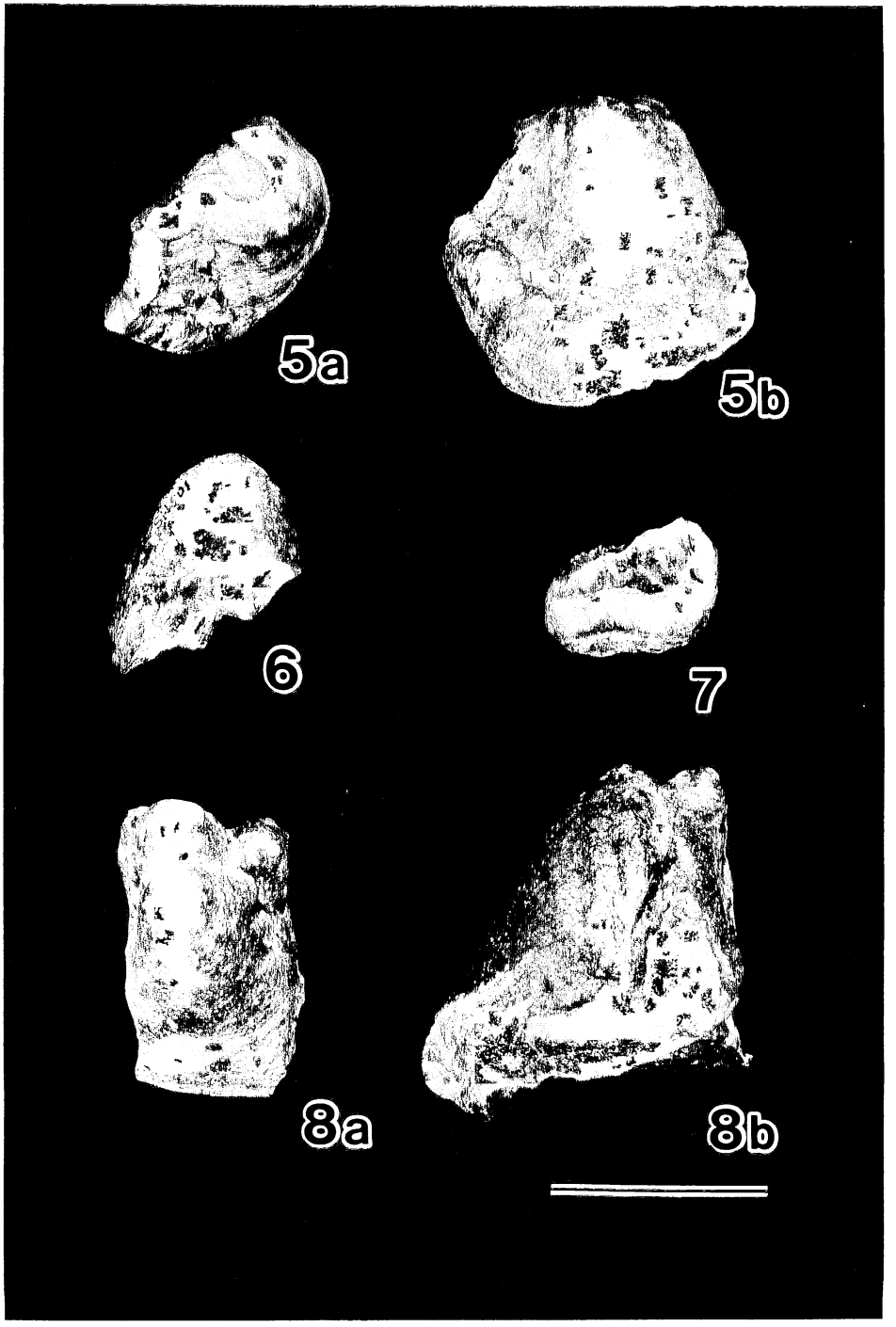
Stegodon kaisensis (scale bar 3 cm)

Fig. 7. Occlusal view of a molar fragment (N-256).

Mammuthus subplanifrons (scale bar 3 cm)

Fig. 8a,b. Occlusal (a) and distal (b) views of a half ridge of a molar (SN-247).

Plate 2



Explanation of Plate 3.

?*Aceratherium* sp. (scale bar 3 cm)

Fig. 9a,b. Buccal (a) and occlusal (b) views of a paracone part of an upper cheek tooth (SN-300).

Unidentified Rhinocerotidae (scale bar 3 cm)

Fig. 10. Lateral view of a cheek tooth fragment (SN-284).

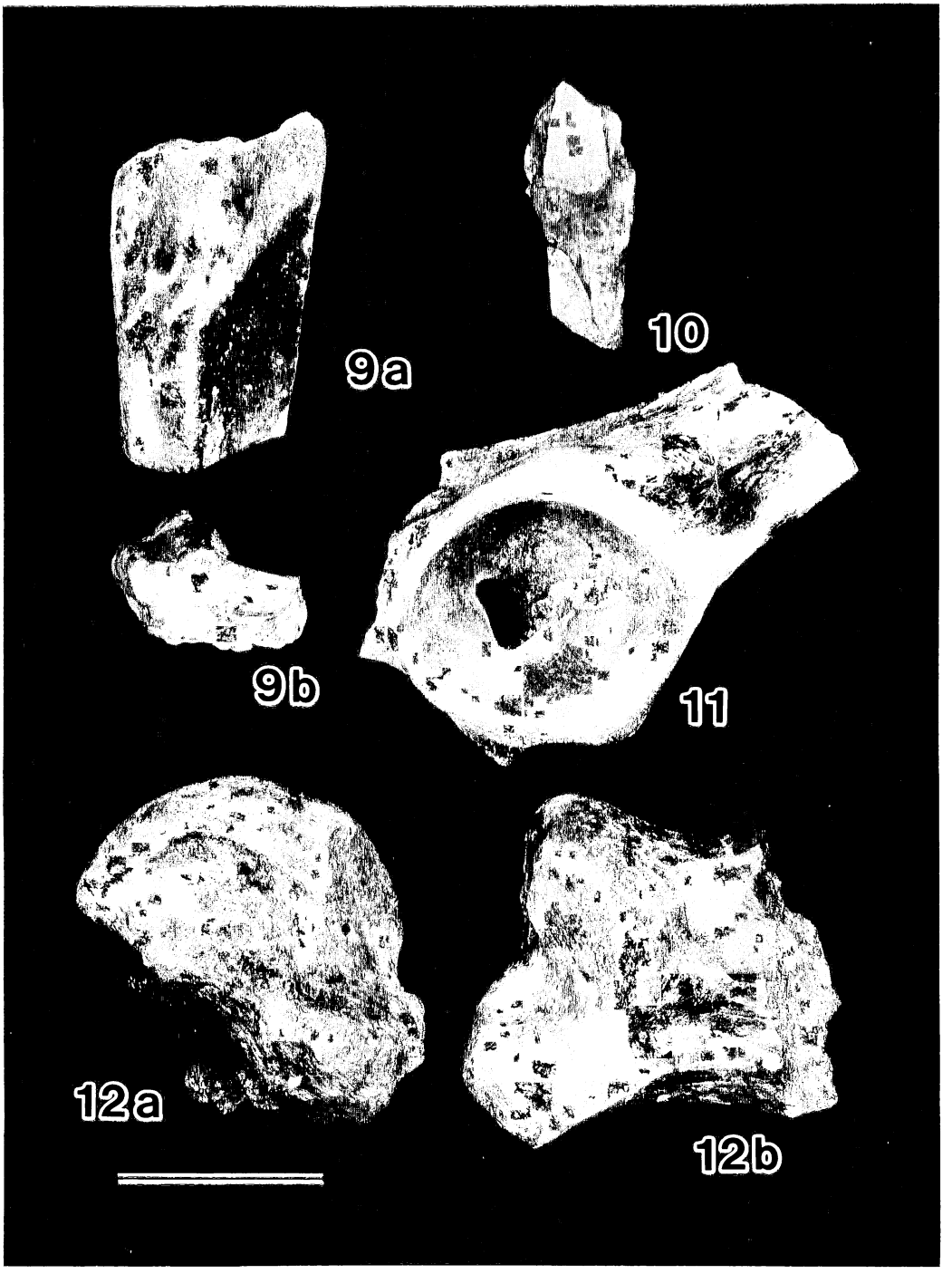
Unidentified Mammalia (scale bar 3 cm)

Fig. 11. A coxal fragment preserving the acetabulum and a part of the ilium (SN-276).

Brachypotherium sp. (scale bar 2.4 cm)

Fig. 12a,b. Medial (a) and anterior (b) views of the left talus (SN-313).

Plate 3



Explanation of Plate 4.

?*Hippopotamus* sp. (scale bar 3 cm)

Fig. 13. Lateral view of probable lower incisor fragments (SN-330A, B, C)

Hippopotamus cf. *imagunculus* (scale bar 3 cm)

Fig. 14a,b. Sectional outline (a) and inferior view (b) of a lower canine fragment (SN-087).

Bovidae gen. et sp. indet. (scale bar 1.5 cm)

Fig. 15a-c. Buccal (a), occlusal (b), and mesial (c) views of the right upper first or second molar (SN-522).

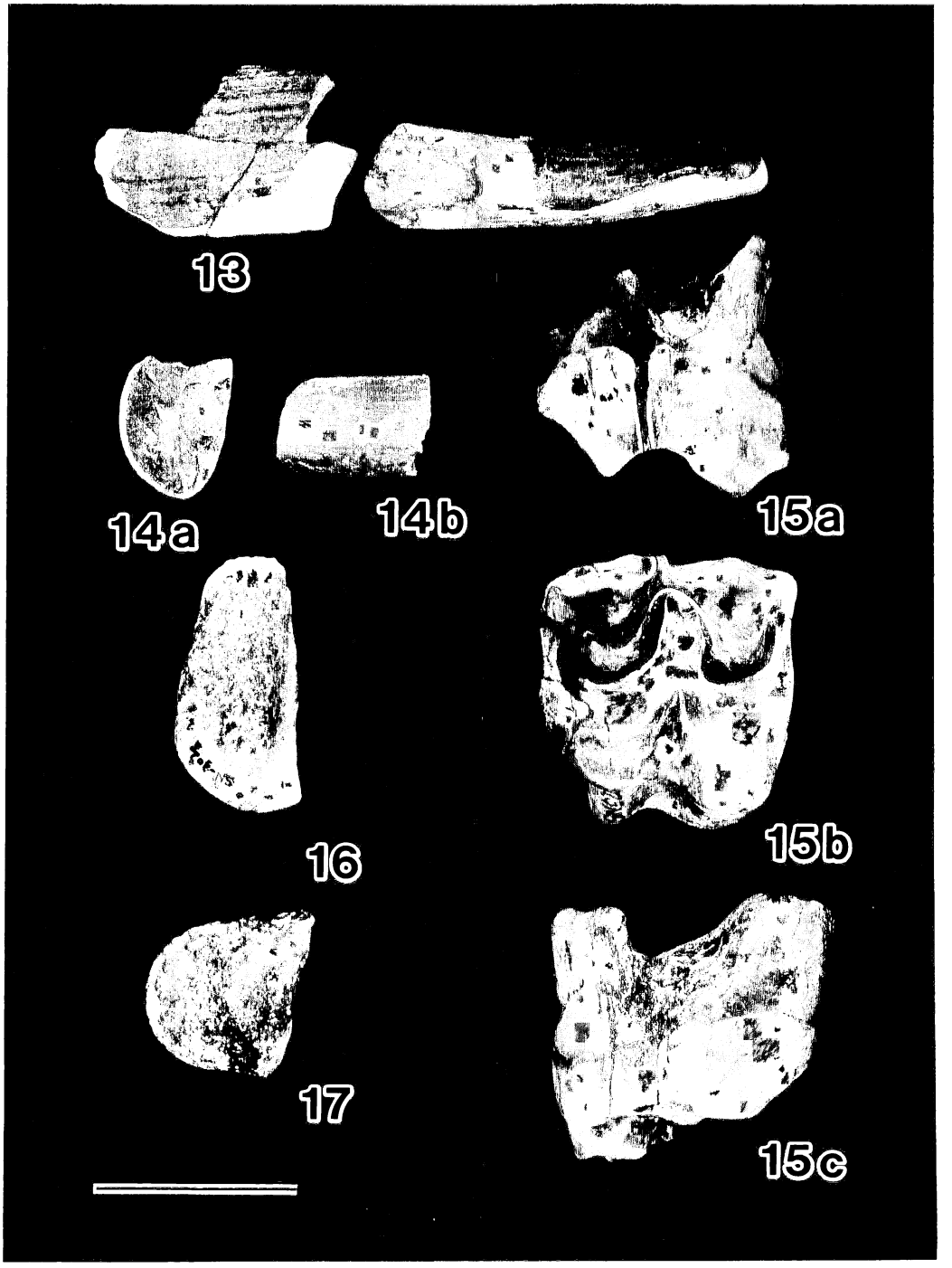
?*Sivatherium* sp. (scale bar 3 cm)

Fig. 16. Buccal view of an enamel fragment of an upper cheek tooth (SN-302).

?*Agriotherium* sp. (scale bar 1.5 cm)

Fig. 17. Occlusal view of a molar fragment (SN-228).

Plate 4



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Turnbull, C. 1965. *Wayward Servants: The Two Worlds of the African Pygmies*. Natural History Press, New York.

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