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Mammalian Fauna from the Neogene Sediments of Myanmar

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Abstract

The terrestrial Neogene sediments are widely exposed along the Ayeyarwady and Chindwin River in central Myanmar and they are divided into three major units: the Freshwater Pegu Beds (Oligocene? to middle Miocene), the Irrawaddy Formation (latest middle Miocene to the early Pleistocene) and the River Terrace deposits (middle to late Pleistocene). A variety of mammalian fossils has been recovered from these sediments and consists of 6 orders, 21 families and 49 genera: Primate (4 genera); Carnivora (4 genera); Artiodactyla (27 genera); Perissodactyla (6 genera) and Proboscidea (8 genera). Myanmar fauna is more similar to the South Asian fauna (Siwalik) than to the East Asian fauna in the Miocene. Faunal interchange between Myanmar and East Asia seems to have started in the late Miocene to the latest Miocene. Faunal interchange among South Asia, East Asia and Myanmar seems to have increased in the early to middle Pleistocene because northern fauna moved southward due to the cooling event in the northern hemisphere.

Key words: Neogene, Irrawaddy Formation, Freshwater Pegu Beds, River Terrace Deposits

Introduction

Neogene is an important period in the geological history because the extant mammals that are familiar in today's ecosystem radiated and evolved from more archaic ancestor during this period. Although marine stratigraphers customarily included the full suit of Miocene through Holocene Epoch as a Neogene, many continental workers preferred to distinguish the Pleistocene Epoch as a Quaternary Period (Ogg et al., 2008). In this article, Miocene through Holocene Epoch is referred as a Neogene Period (24 to 0.01 million years ago) to include the mammalian fossils from the Upper Irrawaddy Formation and River Terrace Deposits.

Mammalian fossils are frequently recovered from the Neogene sediments of central Myanmar, exposed along the Ayeyarwady and Chindwin Rivers. Although these mammalian fossils have been documented since the late 19th Century (e.g. Lydekker, 1876), there are few

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paleontological researches on these fossils. Recently, we have been carrying out fossil expedition in the Neogene sediments of central Myanmar under the supervision of the Ministry of Culture and many mammalian fossils, including primates, were discovered from these sediments. In this article, we describe the geology and biostratigraphy of the Neogeone sediments of Myanmar. Furthermore, we revise the Neogene mammals based on the newly recovered fossil specimens and discuss their temporal change in Myanmar.

Geology and biostratigraphy of Neogene sediments

Myanmar can be divided into four geotectonic provinces from east to west: the Sino-Burman Ranges (=Shan-Tenasserim Massif); the Central Cenozoic Belt (=Inner-Burman Tertiary Basin); the Indo-Burman Ranges (=Arakan-Chin Folded Belt) and the Arakan Coastal Zone (=Arakan Coastal Plain) (Chhibber, 1934; Maung Thein, 1973; Bender, 1983). The continental Neogene sediments are widely distributed along the Ayeyarwady and Chindwin Rivers in the Central Cenozoic Belt and yield a variety of vertebrate fossils (Fig 1). They are mainly composed of fluviatile sediments transported from the Indo-Burman Ranges, Eastern Himalayas and Sino-Burman Ranges, and are characterized by the abundance of silicified fossil woods. They interfinger with the marine deposits of the Oligocene to Miocene Pegu Group (between 20°–22°N) in the northern part of central Myanmar due to marine transgression and regression during the Miocene and later periods (Stamp, 1922).

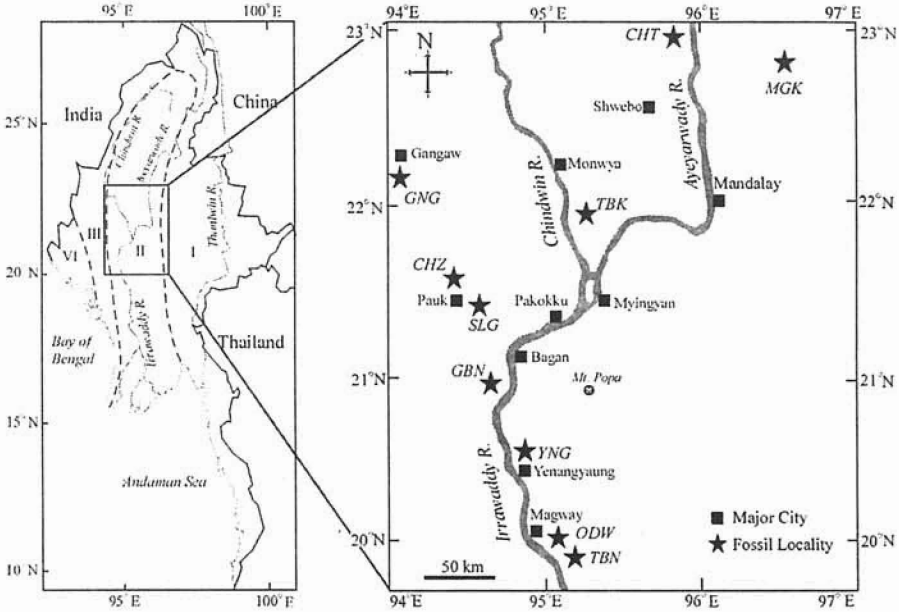

Fig. (1) Map of Myanmar, showing four major geological regions (left) and the Neogene fossil localities of central Myanmar (right). I, Sino-Burman Ranges; II, Central Cenozoic Belt; III, Indo-Burman Ranges; IV, Arakan Coastal Plain. CHT: Chaungtha (M. Mio); GNG: Gangaw (M. Mio.); MGK: Mogok (M. Pleisto.); ODW (L. Mio.); TBK: Thanbinkan (M. Mio.); TBN: Tebingan (M-L. Mio.); YNG: Yenangyaung (L. Mio.-E. Pleisto.); CHZ: Chaingzauk (L. Mio.-E. Plio.); GBN: Gwebin (Plio.- E. Pleisto.); SLG: Sulegon (Plio.- E. Pleisto.)

The terrestrial Neogene sediments of Myanmar consist of three major sedimentary units: the Freshwater Pegu Beds, the Irrawaddy Formation and the River Terrace Deposits. The geological ages of these sediments have been estimated based on the correlation with vertebrate faunas from the Indian Subcontinent and China due to the lack of constrained age calibrated from the radioisotope or paleomagnetism (Fig. 2). Most specimens recovered from these sediments are medium to large sized Artiodactyla (bovids and hippopotamids) and proboscideans, whereas small mammals (rodent and primate) are rare, probably due to the collection bias as well as depositional and environmental factors.

Ma	Geological age		Myanmar		Indian Subcontinent	East Asia	Europe
	Pleistocene		River Terrace Deposits		Boulder conglomerate	Nihewanian	Biharian
	Pliocene	L	Irrawaddy Formation	Upper Irrawaddy	Pinjor	Yushean	Villafranchian
5		E		Lower Irrawaddy	Tatrot		Ruscinian
	Miocene	L			Dhok Pathan	Baodean	Turolian
10					Nagri	Bahean	Vallesian
		M		Freshwater Pegu Beds	Chinji	Tunggurian	Astaracian
15					Kamlial	Shanwangian	Orleanian
20		E			Chitarwata (Upper)	Xiejian	Agenian

Fig.(2) Stratigraphy of Neogene sediments in central Myanmar and their correlations to stratigraphy of Indian Subcontinent and Land Mammal Ages of East Asia and Europe

The Freshwater Pegu Beds consist mainly of sandstone with shale and siltstone layers, and were likely deposited under brackish to fluviatile conditions. The sediments are thick in the northern part (~2600 m) and thin at the southern part (~700 m) due to the transgression of the sea from the south during the Miocene (Stamp, 1922; Aung Khin & Kyaw Win, 1969). Most of the mammals from the Freshwater Pegu Beds show resemblances to those from the Kamlial and Chinji Faunas of the Siwalik Group, suggesting an early to middle Miocene age. On the other hand, Colbert (1938) suggested the Oligocene through to the late Miocene for the Freshwater Pegu Beds due to the occurrence of amynodont *Cadurcotherim*, an anthracothere *Telmatodon* and a tragulid *Dorcatherium* (Table 1)

Table (1) Mammalian fossils from Freshwater Pegu Beds

Artiodactyla	**Perissodactyla**
Suidae	Rhinocerotidae
Conohyus sp.	*"Diceratherium"sp.*
Tetraconodon malensis	*Brachypotherium perimense*
Tetraconodon sp. nov.	*Brachypotherium fatehjangense*

Listriodon sp.	Gen. et. sp. indetermaniate
Antharcotheriidae	Amynodontidae
Microbunodon sp.	*Cadurcotherium* sp.
Hemimeryx sp.	**Proboscidea**
Telmatodon sp.	Deinotheriidae
Tragulidae	*Prodeinotherium* sp.
Dorcatherium sp.	Gomphotheriidae
	Choerolophodon corrugatus
	Gen. et. sp. indetermaniate

(After Colbert, 1938; Takai et al., 2006; Thaung Htike, 2008; Zin Maung Maung Thein, 2010)

The Irrawaddy Formation is traditionally subdivided into the Lower Irrawaddy and Upper Irrawaddy based on the lithological and palaeontological criteria (Stamp 1922; Colbert 1938; Bender 1983), and its thickness has been estimated to be 2000–3000 m (Bender, 1983; Wandrey, 2006). The Lower Irrawaddy consists of cross-bedded sandstone, gravel and pebbly red soil layers with carbonate and iron concretions and is correlated with the Dhok Pathan Formation of the Siwalik Group, suggesting the late Miocene to early Pliocene age. However, the base of the Lower Irrawaddy probably extends to the late middle Miocene because of the occurrence of *Hemimerxy blanfordi*, *Brachypotherium fathejangense*, *Siamotragulus* sp. and *Conohyus* which are the members of the Chinji Fauna of the Indian Subcontinent (Cotter, 1938; Bender, 1983; Chavasseau et al., 2006; Chit Sein, 2006) (Table 2; Fig. 3&4)

The Upper Irrawaddy consists of gravel and poorly consolidated sandstone with a few red soil layers. However, it is difficult to lithologically differentiate between the Upper and the Lower Irrawaddy units in the field without palaeontological evidence. The Upper Irrawaddy has conventionally been referred to the early Pleistocene (Colbert, 1938, 1943; Bender, 1983). The Upper Irrawaddy fauna shows close resemblance to the Tatrot and Pinjor faunas of the Indian Subcontinent, suggesting the extension of its geological age to the late Pliocene (Table 3).

Table (2) Mammalian fossils from Lower Irrawaddy Formation

Primates

Hominoidea

Khoratpithecus sp.

Cercopithecidae

Cf. *Trachypithecus* sp.

Rodentia

Hystricidae

Hystrix sp. nov.

Carnivora

Ursidae

Agriotherium sp. nov.

Amphicyonidae

Amphicyon minor

Hyaenidae

Ictitherium sp.

Artiodactyla

Suidae

Tetraconodon irramagnus

Tetraconodon irramedius

Parachleuastochoerus sp.

Sivachoerus prior

Propotamochoerus hysudricus

Propotamochoerus wui

Hippopotamidae

Hexaprotodon iravaticus

Tragulidae

Dorcatherium sp.

Cf. *Siamotragulus* sp.

Dorcabune sp.

Bovidae

Tragoportax almalthea

Tragoportax cf.*islami*

Pachyportax latidens

Selenoportax

Plesiaddax simplex

Proleptobos birmanicum

Hemibos sp.

Perissodactyla

Rhinocerotidae

Brachypotherium perimense

Rhinoceros sp.

Chalicotheriidae

Gen. et. sp. indet.

Chalicotherium salinum

Equidae

Hipparion antelopinum

Proboscidea

Gomphotheriidae

Sinomastodon

Hexaprotodon sivalensis	Stegodontidae
Antharcotheriidae	*Stegolophodon latidens*
Gen. et. sp. indet.	*Stegolophodon stegodontoides*
Merycopotamus dissimils	*Stegodon elephantoides*
Dorcabune antharcotoides	*Stegodon sp.*
Giraffidae	Mammutidae
Hydaspitherium birmanicum	*Zygolophodon* sp.
Vishnutherium iravaticum	

(After Colbert, 1938; Takai et al., 2006; Chit Sein, 2006; Chavasseau et al., 2006, in press; Thaung Htike 2008; Zin Maung Maung Thein, 2010)

Table (3) Mammalian fossils from the Upper Irrawaddy Formation

Primates	
Cercopithecidae	Bovidae
Cf. *Trachypithecus* sp.	*Proleptobos birmanicus*
Cf. *Semnopithecus* sp.	*Hemibos triquetricornis*
Rodentia	*Bos* cf. *sondaicus*
Hystricidae	*Gazella?*
Hystrix sp.	Hippotragini?
Artiodactyla	*Carpricornis* cf. *sumatrensis*
Suidae	**Perissodactyla**
Sivachoerus prior	Rhinocerotidae
Potamochoerus sp.	*Rhinoceros sondaicus*
Sus sp.	*Dicerorhinus gwebinensis*
Hippopotamidae	*Dicerorhinus cf. sumatrensis*
Hexaprotodon sivalensis	Chalicotheriidae
Hexaprtodon palaeindicus	Cf. *Nestoritherium*

Antharcotheriidae	Equidae
Merycopotamus dissimilis	*Equus yunnanensis*
Tragulidae	**Proboscidea**
Dorcabune sp.	Stegodontidae
Cervidae	*Stegodon insignis birmanicus*
Cervus sp.	*Stegodon* sp.
	Elephantidae
	Elephas husudricus

(After Colbert, 1938; Takai et al., 2007; Thaung Htike, 2008; Zin Maung Maung Thein, 2010)

The River Terrace Deposits are a continuation of the Upper Irrawaddy and probably correspond to the middle Pleistocene to Holocene (De Terra, 1943; Colbert 1943). They are well exposed along the Ayeyarwady River between Thabeitkyin and Magway (De Terra, 1943). The age of these deposits has been considered the middle to late Pleistocene and its fauna mostly contains extant genera, some of which are probably rewashed from the Upper Irrawaddy. The other middle Pleistocene faunal assemblage (*Ailuropoda-Stegodon* fauna) was reported from the Mogok cave in Mandalay Division (Colbert, 1943) (Table 4).

Table (4) Mammalian fossils from River Terrace/Cave Deposits

Primates	
Cercopithecidae	Cervidae
Cf. *Procynocephalus* sp.	*Cervus* sp.
Rodentia	Bovidae
Hystrix sp.	*Bos* sp.
Carnivora	*Hemibos triquetricornis*
Ursidae	**Perissodactyla**
Ailuropoda baconi	Rhinocerotidae

Hyaenidae	*Rhinoceros* sp.
Cf. *Pachycrocuta* sp.	**Proboscidea**
Artiodactyla	Stegodontidae
Suidae	*Stegodon orientalis*
Sus scrofa	Elephantidae
Hippopotamidae	*Elephas namadicus*
Hexaprtodon palaeindicus	*Elephas hysudriucs*

(after Colbert, 1938, 1943; Takai et al., 2006; Zin Maung Maung Thein, 2010)

Fig.(3) Left mandibular fragment of a large porcupine, *Hystrix* sp. nov. from the Lower Irrawwady Formation at the Chaingzauk Area, Pauk Township, Magway Division

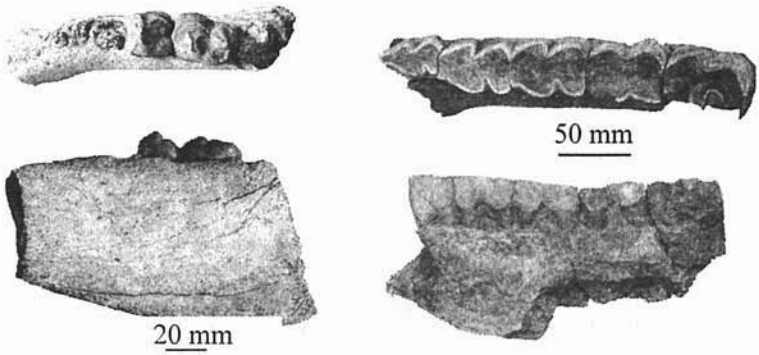

Fig. (4) **A**, left mandibular fragment with P_4–M_1 of an extinct bear, *Agriotherium* sp. nov.; **B**, left mandibular fragment with P_3–M_2 of a rhinoceros, *Rhinoceros* sp. from the Lower Irrawaddy Formation at the Chaingzauk Area, Pauk Township, Magway Division

Neogene mammals and their temporal change in Myanmar

In the early Miocene, most areas of the central Myanmar were under shallow marine conditions, leaving only a few fragmentary mammalian fossils such as those of the anthracothere *Telmatodon* (Colbert, 1938; Wandrey, 2006). In the middle Miocene, the continental condition gradually prevailed in central Myanmar (Aung Khin and Kyaw Win, 1969; Wandrey, 2006). This period is characterized by the occurrence of several mammals including bears (*Amphicyon*), tragulids (*Dorcatherium*), boars (*Conohyus*, *Tetraconodon* and *Listriodon*), anthrachotheres (*Microbunodon*, *Hemimeryx* and *Telmatodon*), rhinoceros ("*Diceratherium*", *Brachypotherium* and Rhinocerotidae indet.) and elephants (*Prodeinotherium*, *Choerolophodon* and Gomphotheriidae indet.). This faunal assemblage corresponds to the lower and middle Siwalik Fauna of the Indian subcontinent, supporting that the Indian subcontinent and Southeast Asia were in the same biogeographic province since the middle Miocene, as suggested by Ducrocq (1994).

These archaic mammals declined in the late Miocene and several new mammals appeared in this period. The porcupine (*Hystrix*), carnivores (*Agriotherium* and *Ictitherium*), tragulids (*Dorcabune*), giraffids (*Hydaspitherium* and *Vishnutherium*), suids (*Propotamochoerus*),

anthracotheres (*Merycopotamus*), modern rhinoceros (*Rhinoceros*), equids (*Hipparion*) and elephants (*Stegolophodon* and *Stegodon*) first appeared in this period. Furthermore, bovids became diversified (*Tragoportax*, *Selenoportax*, *Pachyportax*, *Proleptobos* and *Plesiaadax*) which coincided with the global expansion of C_4 grasslands. On the other hand, the colobine monkey (cf. *Trachypithecus*), suid (*Sivachoerus*), elephant (*Sinomastodon*) and hippopotamus (*Hexaprotodon*) probably appeared in the latest Miocene. The faunal interchange between Myanmar and East Asia seems to have started in the late Miocene to the latest Miocene with the appearance of *Agriotherium*, *Sinomastodon*, *Propotamochoerus* and *Plesiaddax* in both faunas.

Most mammalian taxa from the late Miocene, such as *Propotamochoerus*, *Sivachoerus*, *Selenoportax*, *Merycopotmaus*, *Dorcabune*, *Rhinoceros*, *Stegodon* and *Stegolophodon* seem to have survived until the end of Pliocene.

In the early Pleistocene, members of the northern fauna moved southward due to the cooling event in the northern hemisphere (Tougard, 2001), and the faunal exchange among South Asia, East Asia and Southeast Asia seems to have increased. In the Pleistocene, most of the Pliocene mammalian taxa survived, but some were replaced by derived forms such as *Potamochoerus* sp, *Hexaprotodon palaeindicus*, *Stegodon insignis birmanicus* and *Elephas hysudricus*. Furthermore, colobine (cf. *Semnopithecus*), cervid (*Cervus*), rhinoceros (*Dicerorhinus*) and several new bovids (*Hemibos*, *Bos*, *Capricornis*, *Boselaphus*, *Gazella* and *Hippotragus*) appeared in this period.

In the middle to the late Pleistocene, most archaic genera gradually disappeared, and extant genera, such as *Ailuropoda*, cf. *Pachycrocuta*, *Hystrix*, *Sus*, *Cervus*, *Bos*, *Bibos*, *Equus*, *Rhinoceros* and *Elephas*, became dominant.

Summary

Neogene sediments of Myanmar can be divided into three major units: the Freshwater Pegu Beds (Oligocene? to middle Miocene), the Irrawaddy Formation (latest middle Miocene to the early Pleistocene) and the River Terrace Deposits (middle to late Pleistocene). To date, 6 orders (Primate, Rodent, Carnivora, Perissodactyla, Artiodactyla, Proboscidea), 21

families and 49 genera of mammalian fossils are recognized from these sediments. In the early Miocene, most areas of the central Myanmar were under shallow marine conditions, leaving only a few fragmentary mammalian fossils. In the middle Miocene, several mammals appeared in this period and correspond to the lower and middle Siwalik Fauna of the Indian Subcontinent. In the late Miocene, archaic mammals declined and several new mammals appeared in this period. Furthermore, faunal interchange between Myanmar and East Asia seems to have started in this period. Most mammalian fauna from the late Miocene seem to have survived until the end of Pliocene. Faunal interchange among Myanmar, South Asia and East Asia seems to have increased in the early to middle Pleistocene because northern fauna moved southward due to the cooling event in the northern hemisphere.

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