

FOSSIL RHINOCEROSSES OF MYANMAR

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Abstract

Rhinoceroses, the family Rhinocerotidae, currently inhabit in Africa and South and Southeast Asia. In the fossil record, this family was diversified into many genera and species, and was widely distributed throughout North America, Asia, Europe and Africa in the geological past. In Myanmar, fossil remains of rhinoceroses have been documented in the late Eocene Pondaung Formation belonging to one species (cf. *Teletaceras* sp.). However, remains of rhinoceros are common in the Neogene of central Myanmar representing four genera ("*Diceratherium*" *naricum*, *Brachypotherium perimense*, *Brachypotherium fatehjangense*, *Rhinoceros sondaicus*, *Rhinoceros* sp., *Dicerorhinus gwebinensis*, *Dicerorhinus* sp.) and one indeterminate genus (total eight species). Neogene rhinoceros of Myanmar are also commonly known in the Indian Subcontinent, indicating the possible faunal exchanges between these regions. However, presence of some faunal elements such as elephant (*Sinomastodon* sp.) and wild boar (*Propotamochoerus* sp.) in the Pliocene or later period suggests a possible faunal exchange with East Asia.

Keywords: Irrawaddy Formation, Neogene, Pondaung Formation, Rhinocerotidae, systematic paleontology

Introduction

The family Rhinocerotidae first arose in the Eocene as one clade of the superfamily Rhinoceroidea together with Hyracodontidae and Amynodontidae. This family is now in the danger of extinction, and its distribution is limited to Africa and Asian Region (Martin *et al.*, 2001). However, it was diversified into many genera and species, and was widely distributed throughout North America, Asia, Europe and Africa in the geological past (Prothero *et al.* 1989). In Myanmar, fossil remains of rhinoceroses are recovered from the late Eocene Pondaung Formation and Neogene sediments of central Myanmar. However, rhinoceros remains of Pondaung Formation are fragmentary and have been tentatively assigned to archaic genus, *Teletaceras* sp. (Holroyd *et al.*, 2006). However, remains of rhinoceros are common in the Neogene sediments of central Myanmar representing seven species belonging to four genera. In this work, we carry out the systematic paleontology of the newly discovered rhinoceros fossils from

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the Neogene sediments of central Myanmar and then review the phylogenetic status of the fossil rhinoceroses of Myanmar.

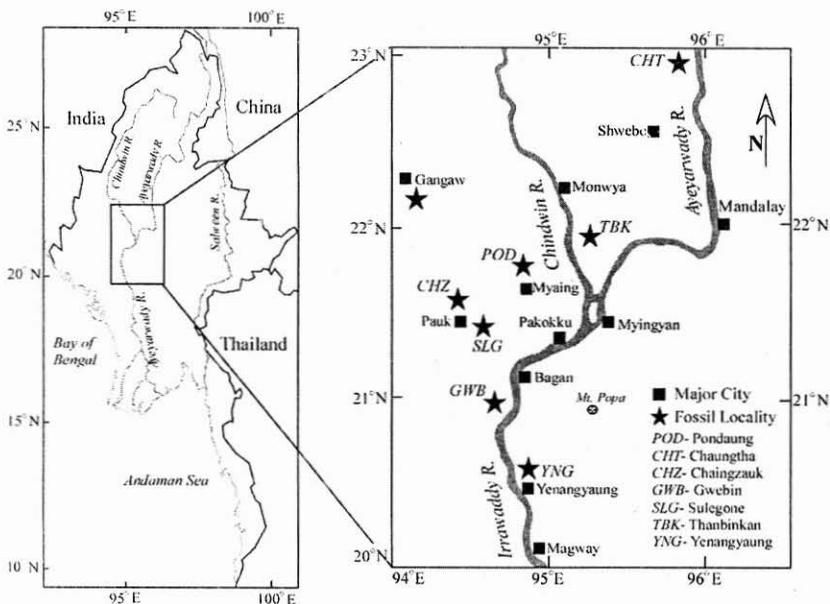


Figure (1) Fossil localities of rhinoceroses in central Myanmar

Geological Setting

Cenozoic sediments are widely distributed along the Ayeyarwady and Chindwin Rivers in central Myanmar. These sediments are assumed to be the product of the infilling of Burmese Gulf by river-borne sediments of the proto-Ayeyarwady River in the north and by marine sedimentation in the south (Stamp, 1922). This process of infilling of the Burmese Gulf was not a simple progressive advance of continental sediments and a consequent retreat of marine deposition. It took the form of a series of cycles of marine and continental sedimentation (Colbert, 1938). Consequently, Cenozoic stratigraphy of Myanmar is not a simple succession of broad, well-defined depositional units. It is characterized by complexly interfingering marine and

continental beds, with numerous local differences causing many lateral variations in the lithology and the thickness of the several formations, and alteration of horizons containing marine and terrestrial fauna (Stamp, 1922; Colbert, 1938).

Vertebrate fossil bearing Cenozoic sediments of Myanmar mainly belong to four formations (1) Pondaung Formation (2) Fresh water Pegu Beds (3) Irrawaddy Formation and (4) River Terrace Deposits.

Pondaung Formation: It is lithologically subdivided into the Lower Member and Upper Member. The mammalian fossils were usually recovered from the lower half of the Upper Member (Aye Ko Aung, 2004). The age of the Pondaung mammalian fauna has been estimated as latest middle Eocene based on the marine fossils of the underlying middle Eocene Tabyin Formation and overlying late Eocene Yaw Formation (Holroyd and Ciochon, 1994), the nanoplankton (Hla Mon, 1997) and floral assemblages (Thet Wai, 1997) and Fission-track age (37.2 Ma) calibrated from tuffaceous sediments from one of the Pondaung fossil localities (Tsubamoto et al., 2002).

Freshwater Pegu: The Pegu Group (Oligocene to middle Miocene) is mainly composed of the marine sediments in the lower part in the south and continental in the upper part in the north, where transition boundary occur in the area between 20°N and 22°N latitudes (Stamp, 1922; Aung Khin and Kyaw Win, 1969; Bender, 1983) (Fig. 2). This is due to the fact that gulf was existed in the region between Western Ranges and Eastern Highland during the Oligo-Miocene time (Krishnan, 2005). Sediments gradually filled up this gulf when the sea was receding southward. These continental sediments of Pegu Group are usually referred as Freshwater Pegu (Stamp, 1922; Colbert, 1938) or Fresh water Formation of Pegu Group (Aung Khin and Kyaw Win, 1969).

Colbert (1938) suggested the late Oligocene through the late Miocene age for this fluvatile beds based on the few scattered mammalian fossil like *Cadurcotherium*, *Telmatodon* and *Dorcatherium*. Cotter (1938) also reported *Aceratheium*, *Tetrabelodon*, *Hemimeryx*, *Antharcotherium* and *Deinotherium* from the Maw gravels (equivalent with Freshwater Pegu) and suggests its correlation with the lower Siwalik Group (Kamlial Formation).

Irrawaddy Formation: The fluvatile sediments of Irrawaddy Formation are traditionally subdivided into upper and lower parts (Colbert, 1938; Bender, 1983). The Lower Irrawaddy Formation has been correlated to the Dhok Pathan Formation of the Siwalik Group, suggesting an age of the late Miocene

to early Pliocene. However, the base of the Lower Irrawaddy probably extends to the late middle Miocene because some taxa from the Lower Irrawaddy, such as *Hemimeryx blanfordi*, *Brachypotherium fatehjangense*, *Siamotragulus* sp., and *Conohyus*

thailandicus also occur in the Chinji Fauna of Indian Subcontinent .

The Upper Irrawaddy sediments have been conventionally referred to the early Pleistocene (Colbert, 1938, 1943; Bender, 1983). However, the Upper Irrawaddy fauna shows close resemblances to the Tatrot and Pinjor faunas of the Indian Subcontinent, suggesting a late Pliocene to early Pleistocene correlation for the Upper Irrawaddy sediments.

River Terrace Deposits: These deposits conformably overlie the Upper Irrawaddy sediments and probably correspond to the middle Pleistocene to Holocene (De Terra, 1943; Colbert, 1943). The fauna of the River Terrace Deposits contains many extant genera, but it includes some reworked fossils from the Upper Irrawaddy sediments (Colbert, 1943).

Materials and methods

The specimens (MUDG-V) described here are housed in the Department of Geology, University of Mandalay except one (BGM-Pkk) which is displayed at the Fossil Museum of Botanical Garden, Pyin Oo Lwin Township. The taxonomy used in this paper follows that of Prothero and Schoch (1989). The terminology of anatomical designations and corresponding measurements generally follow the convention by Guerin (1980) (Fig. 3).

Institutional abbreviations. MUDG-V= Mandalay University Department of Geology- Vertebrate; BGM-Pkk= Botanical Garden Fossil Museum-Pakokku

Anatomical abbreviations. I1/, first upper incisor; P1/, first upper premolar; M1/, first upper molar; I/1, first lower incisor; P/1, first lower premolar; M/1, first lower molar.

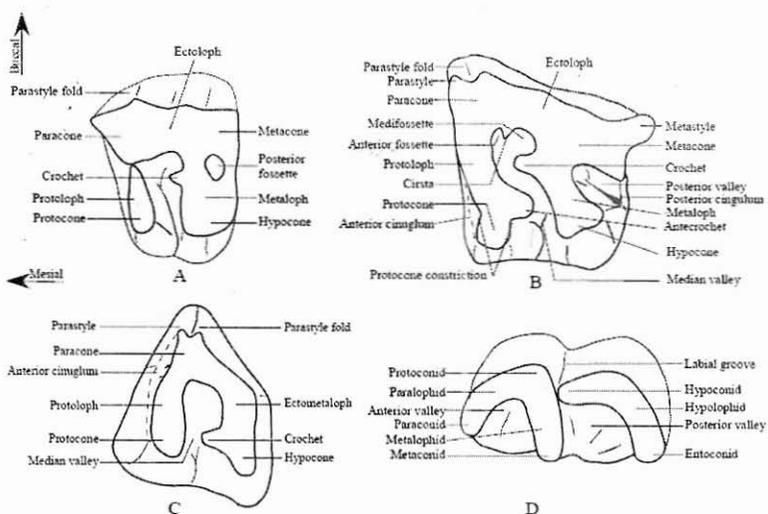


Figure (2) Terminology of rhinoceros cheek teeth (modified after Guerin, 1980). A, left P3; B, left M1; C, left M3; D, right M/1.

Systematic Paleontology

Order Perissodactyla Owen, 1848

Family Rhinocerotidae Owen, 1845

Genus *Teletaceras* Hanson, 1989

cf. *Teletaceras* sp.

Comment: The upper member of the Pondaung Formation yields the dental remains of rhinoceros that can be referable to the basal member of the family Rhinocerotidae (Holroyd et al., 2006). Due to the fragmentary nature of the specimens, they were tentatively assigned to the primitive rhinoceros, *Teletaceras* sp. which was also documented from the late Eocene Clarno Formation of North America (Hanson, 1989).

Subfamily Dicertheriinae Dollo, 1885

Genus *Diceratherium* Marsh, 1875

Diceratherium naricum Pilgrim, 1912

Comment: *Diceratherium*, paired-horned rhinoceros, seems to have originated in North America during the late Oligocene and distributed into Eurasia in the early Miocene (Prothero and Schoch, 2002). In Myanmar, it has been reported from the middle Miocene Maw Beds (equivalent to Fresh water Pegu Beds) in Gangaw, Magway Region, together with *Aecratherium perimense*, *Tetrabelodon falconeri*, *Hemimeryx blanfordi*, *Anthracotheerium silistrense* and *Dinotherium pentapotamia* (Cotter, 1938). However, he did not describe the systematic description or depository of the referred specimens, and it is difficult to assess the validity of *Diceratherium* in Myanmar. Furthermore, some researchers suggested that Asian Diceratheriinae is different from the North American *Diceratherium* and the former description of this genus from the northern China can be corresponding to the Aceratheriini rhinoceros (Bohlin, 1937; Qiu and Yang, 1982). Thus, *Diceratherium naricum* of Myanmar has possibility belonging to the Aceratheriini rhinoceros.

Subfamily Aceratheriinae Dollo, 1885

Genus *Brachypotherium* Roger, 1904

Brachypotherium perimense Falconer and Cautley, 1847

Referred materials. —MUDG-V 1045, a right M3/; MUDG-V 1131, a left M3/

Horizon and Age. — Freshwater Pegu Beds; Middle Miocene

Locality. —Thanbinkan (21° 58' 35" N; 95° 21' 30" E), Chaung-U Township, Sagaing Region



Figure (3) Isolated molars of *Brachypotherim perimense*. A. MUDG-V 1045, a right M3/; B. MUDG-V 1131, a left M3/. (Scale bar-5 cm)

MUDG-V 1045: The triangular shape teeth is moderately worn out; the enamel is generally thick; the ectometaloph is pointed lingually; the protocone is weakly constricted off; the crochet is small and directs mesially; the crista is absent; the antecrochets is present but not pronounced; an anterior cingulum is terminated at the mesial part of protocone; the small slanted posterior cingulum is observed in the distal edge of the tooth below the hypocone; the lingual cingulum is absent; the median valley is wide and the small tubercles are observed at the entrance (Fig. 3A). (Tooth Dimension: Length (Lingual) = 52.3 mm; W1 (Protoloph) = 58.4 mm; W2 (Ectometaloph) = 65.2mm)

MUDG-V 1131: The tooth is deeply worn down to the level of anterior cingulum and broken at the labial part. The enamel is thick at the lingual part of the protoloph and thin on the median valley; the crochet is moderately developed; neither protocone constriction nor antecrochet is distinct; the ectometaloph is pointed lingually; a vertical groove runs down at the lingual end of ectometaloph wall and is terminated by posterior cingulum; the two large tubercles are present at the entrance to the median valley (Fig. 3B). (Tooth Dimension: Length (Lingual) = 52 mm; W1 (Protoloph) = 60 mm; W2 (Ectometaloph) = 64 mm)

Brachypotherium is a large, hornless rhinoceros and distributed in the Miocene of Old World, and survived until the late Pliocene in East Africa (Hessig, 1989; Prothero and Schoch, 2002). In the neighbouring region of Myanmar, it has been discovered from the lower and middle Siwaliks of Indian subcontinent (Hessig, 1972; Welcomme et al., 2001), from the early Miocene of China (Qiu, 1990; Tong, 2001) and from the early late Miocene of Thailand (Chaimanee et al., 2004). Remains of this rhinoceros are recovered from the Freshwater Pegu and Lower Irrawaddy Formation in Myanmar (Takai et al., 2006). Besides *B. perimense*, dental remains of *B. fatehjangense* and indeterminate rhinoceros are documented from the middle Miocene Chaungtha area in Kanbalu Township, Sagaing Region (Chavasseau et al., 2006). *Brachypotherium* from Myanmar has been usually referred to genus *Aceratherium* (Lydekker, 1876; Colbert, 1938). However, Zin Maung Maung Thein et al. (2010) consider the previous description of *Aceratherium* from the Irrawaddy Formation as an invalid taxon, and refer them to *B. perimense*.

Tribe Rhinocerotini Hay, 1902

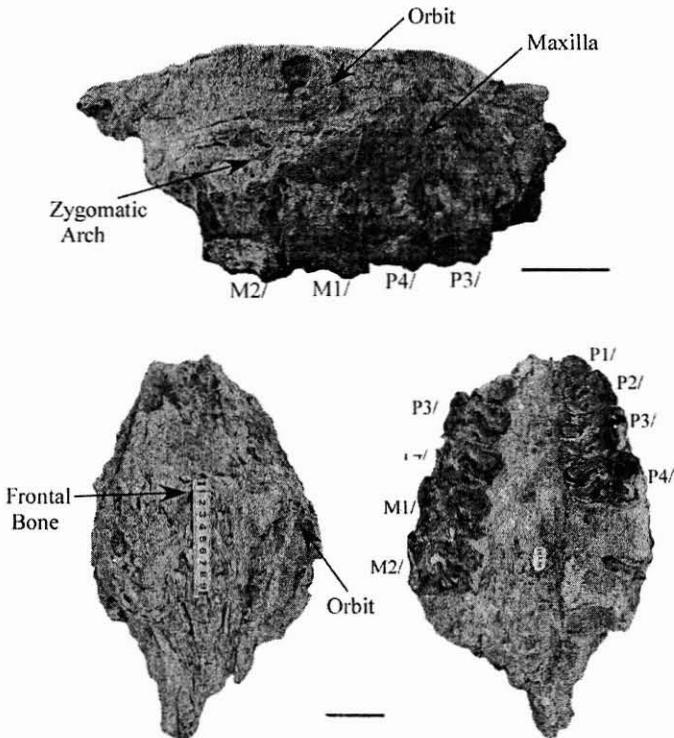
Genus *Rhinoceros* Linnaeus, 1758

Rhinoceros sondaicus Desmarest, 1822

Referred material: BGMF-Pkk- 18, a fragment of skull with left P1/–P4/ and right P3/–M2/; the zygomatic arch, nasal and occipital portion is broken (Fig. 4 A-C).

Horizon and Age: Irrawaddy Formation, Plio-Pleistocene

Locality: Unknown, Pakokku Township, Magway Region



Description: The skull is broken in the nasal and occipital parts. There is no rugose area or horn boss on the frontal bone. The premaxilla is not preserved. The rounded anterior border of the orbit is located at the level between P4/ and M1/ and connects laterally with the base of zygomatic arch. Although the zygomatic arch is broken on both sides, the anterior end of the arch is preserved on the right side, indicating its anterior position at the level of M1/.

On the ventral view, the palate is partly covered with the matrix and ends at the level of M2/. The upper dentition is moderately worn, and especially M1/ is worn down to the level of the posterior cingulum. Neither protocone constriction nor antecrochet is observed. There is no lingual cingulum or tubercle at the entrance to the median valley. The premolars are molarized. On the right teeth row, only P4/ to M2/ are preserved whereas P1/ to P4/ are preserved on the left. On the premolars, the anterior valleys are markedly deeper than posterior one, however the former are nearly same depth with the latter on the molars.

BGFM-Pkk- 18 is assigned to the genus *Rhinoceros* based on the following preserved cranial and dental characteristics: the frontal horn boss is absent; the anterior border of the orbit is located at the level between P4/ and M1/; the protocone is not constricted off; the antecrochet and lingual cingulum are absent and the anterior valleys are deeper than the posterior ones in premolar, and vice versa or nearly same depth in molars (Groves, 1983; Laurie et al., 1983). This specimen is referred to *R. sondaicus* in the presence of the distinct parastyle fold and moderately developed molar crochet, the lingually concave profile of the ectoloph, and in the absence of the crista and protocone fold in the upper molars (Pocock, 1943; Hooijer, 1946; Guerin, 1980)

Rhinoceros is a common rhinoceros in the Indian subcontinent, China and Southeast Asia in the late Neogene, and still survives in the tropical environment of the South and Southeast Asia, represented by Indian rhinoceros (*R. unicornis*) and Javan rhinoceros (*R. sondaicus*) (Nowak, 1991; Prothero and Schoch, 2002).

The extinct species, *R. sivalensis* have also been documented from the Irrawaddy Formation (Colbert, 1938). However, descriptions of this species from Myanmar are based on the fragmentary dento-gnathic materials, and they are relatively smaller than those from the Upper Siwalik Group, suggesting the taxonomic assignment is dubious. (Zin Maung Maung Thein et al., 2010). Furthermore, Antoine et al. (2012) suggest that *R. unicornis* encompasses all large Rhinoceros remains from South Asia that were formerly included within the wastebasket species *R. sinensis*, the Javan *R. kendengindicus* (Bacon et al., 2008; Hooijer, 1949), as well as the Indo-Pakistani *R. sivalensis*, *R. palaeindicus*, *R. deccanensis*, *R. sinhaleyus*, or *R. kagavena* (Tong, 2001).

Subtribe Dicerorhinina Ringstrom, 1924

Genus *Dicerorhinus* Gloger, 1841

icerorhinus gwebinensis Zin Maung Maung Thein et al.,
2008

Comment: *D. gwebinensis* is a small two-horned rhino from the Upper Irrawaddy Formation discovered from Gwebin area in Seikpyu Township, Magway Region. It is morphologically distinct from the extant species *D. sumatrensis* in having the comparatively shorter nasal, the more concave dorsal profile of the skull, the more elevated occiput and presence of molar crista on M3/ (Zin Maung Maung Thein et al., 2008). Furthermore, a mandible that can be referable to extant species *Dicerorhinus* cf. *sumatrensis* has also been reported from Sulegon Area in Pauk Township, Magway Region (Zin Maung Maung Thein et al., 2010)

Conclusion

To date, nine species belonging to five genera of fossil rhinoceroses have been documented from Myanmar. Among them, Pondaung rhinoceros is the first middle Eocene record of family Rhinocerotidae in Southeast Asia and useful for the correlation between the North American and Asian fauna during the Eocene.

In the Neogene, several rhinoceros genera have been recorded from the Freshwater Pegu and Irrawaddy Formation. However, generic status of paired horn rhinoceros *Diceratherium* from the former is uncertain due to unavailability of the fossil materials of previous researchers. Fossil materials of *Brachypotherium perimense*, *B. fatehjangense* and Rhinocerotidae indeterminate are recovered from the middle to late Miocene. This rhinoceros fauna corresponds to the lower and middle Siwalik fauna of the Indian Subcontinent (Colbert, 1935; Heissig, 1972). The co-occurrence of several mammalian taxa, such as wild boars (*Conohyus* sp. and *Tetraconodon* sp.), rhinoceros (*Brachypotherium* sp.) and elephants (*Prodeinotherium* sp., *Choerolophodon* sp. and trilophodont gomphothere) in both faunas supports that the Indian Subcontinent and Southeast Asia were in the same biogeographic province since the middle Miocene

In the late Miocene to early Pleistocene, the extant Asiatic genera, *Rhinoceros* (late Miocene to Pleistocene) and *Dicerorhinus* (Plio-Pleistocene) first appeared. The coexistence of *R. sondaicus* and *Dicerorhinus* in the pre-Pleistocene or early Pleistocene of Myanmar suggests these taxa originated in the Continental Asia as early as the early Pleistocene and migrated to the Island Southeast Asia in the late early Pleistocene.

Neogene rhinoceros of Myanmar are also commonly known in the Indian Subcontinent, indicating the possible faunal exchanges between these regions. However, presence of some faunal elements such as *Sinomastodon* (Gomphotheriidae) and *Propotamochoerus* (Suidae) in the Pliocene or later period suggests a possible faunal exchange with East Asia.

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