REPTILIAN REMAINS OF IRRAWADDY FORMATION IN YINSEIK AREA, MAGWAY REGION

Khaing Myat Thwin[1], Zin Maung Maung Thein[2]

Abstract

Yinseik area occupies Obogon Formation (Middle Miocene) and Irrawaddy Formation (Late Miocene to Early Pleistocene). The dominant lithology of Obogon Formation is an alternation of yellowish brown- to buff-colored, fine to medium-grained, thin-bedded sandstone and light gray to bluish gray clay and shale with fine- to medium-grained sandstone. Irrawaddy Formation is mainly composed of thick bedded to massive, medium to coarse-grained, light gray to light brown, concretionary sandstone with cross stratification in the lower part and massive, medium to coarse-grained, light gray to yellowish brown, gritty to pebbly, incoherent sandstone interbedding with siltstone in upper part. The sediments of Irrawaddy Formation in research area yields the fossilized remains of primate (*Khoratpithecus* sp), carnivores, Anthracothere (*Merycopotamus* sp.), tragulid, wild boar (*Tetraconodon* sp. and *Propotamochoerus* sp.), bovids, rhinoceros (*Rhinoceros* sp.), horse (*Hipparion* sp.), elephant *(Stegolophodon* sp.) and crocodile (*Gavialis* sp.) which occur in the sediments of Irrawaddy Formation. The present faunal assemblage suggests the existence of forest/woodland adapted animals in Yinseik area in the geological past. Occurrence of crocodile (*Gavialis* sp.) and extinct river shark (*Glyphis* sp.) in this area supports the presence of riverine environment. Present day's environmental conditions in Central Myanmar are characterized by a subtropical semi−arid climate especially in most parts of Mandalay and Magway Regions. The vegetation of this region is dominated by open shrub lands and grasslands. Therefore, the occurrence of forest dwelling mammals in present area contributes to the implication that the Late Miocene paleoenvironment of Yinseik area was drastically different from the present day's conditions in central Myanmar.

Keywords: Irrawaddy Formation, *Gavialis* sp., Paleoenvironment.

Introduction

Myanmar has a lot of vertebrate fossils existing Mesozoic and Cenozoic Strata especially Pondaung Formation (Late Eocene) and Irrawaddy Formation (Late Miocene to Early Pleistocene). These fossils are very important in exploring paleoclimate, paleoenviroment, paleoecology and paleontology. The present research is mainly conducted on crocodile's remains in the sediments of Irrawaddy Formation.

Yinseik area is situated about 20 km south of Magway Township, lying on the eastern side of Ayeyarwaddy River (Fig 1). Therefore, it is easily accessible throughout the year. The research area is 12 kilometers long in north-south direction and 12 kilometers wide in east-west direction, covering an area of 144 square kilometers of flat plain and low-lying rolling hill.

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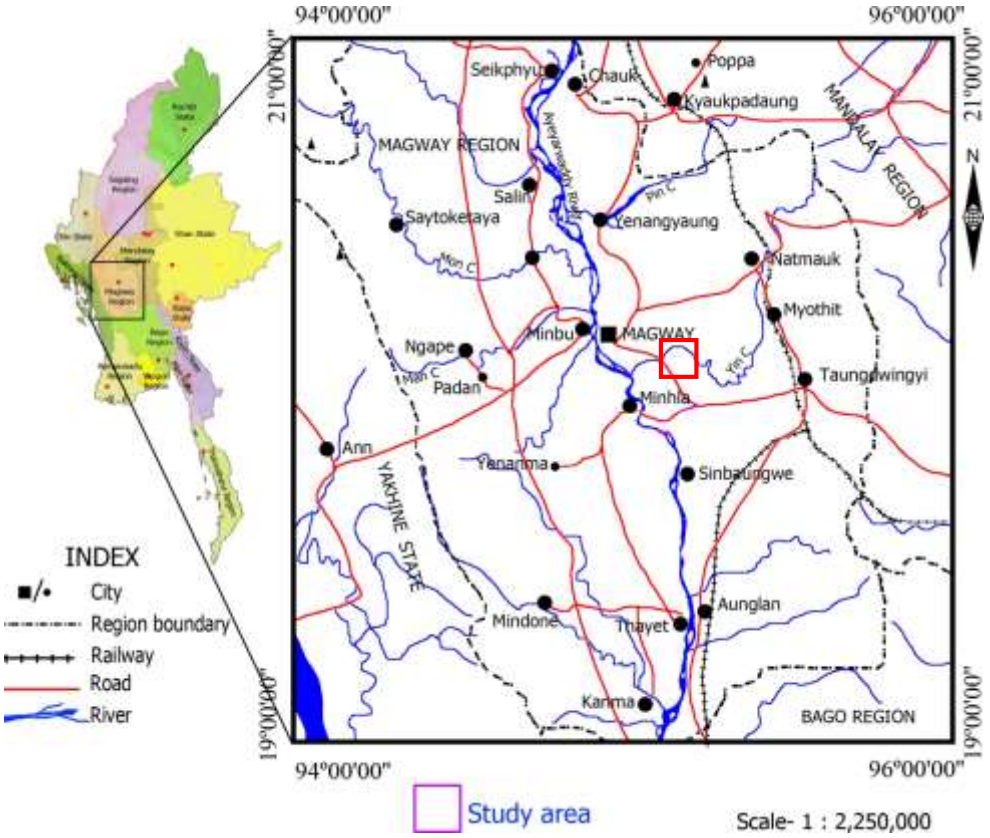


Figure 1 Location map of Yinseik area, Magway Township

The research area is mainly composed of clastic sediments which is dissected and eroded by Yin Chaung (Yin stream) and its tributaries. The largest stream is Yin Chaung which passes through the area from east to west. The most prominent drainage patterns of the area are dendritic, trellis and rectangular (Figure 2). Yin Chaung, flows from east to west and then joined with the Ayeyarwaddy River in the west of the research area.

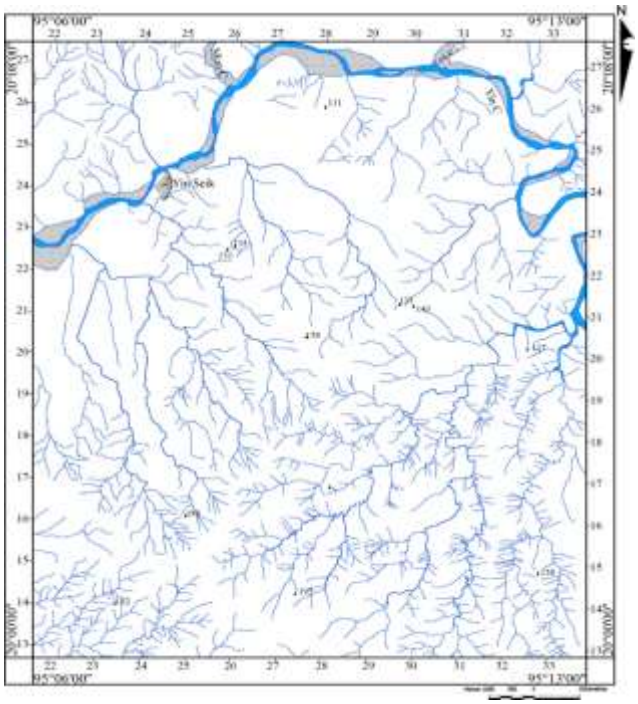


Figure 2 Drainage Pattern of Yinseik area, Magway Township

Aims and Objectives

The main aim of this research is to explore systematic paleontology and paleoecology based on *Gavialis* sp. of Irrawaddy Formation. The research has been carried out with the followings:

(1) To prepare the geological map

(2) To describe the systematic paleontology of *Gavialis* sp.

(3) To evaluate the paleoecology of research area

Methodology

The UTM topographic map 1:50000 and satellite images are used for the location, linear structure and topography, general structural elements and regional structures.

The dips and strike of the beds, joints, folds and faults were studied and measured in the field by using Brunton Compass. The certain location of outcrops is attained by GPS navigator and checked by bearing and intersection methods. The diagnostic fossils were collected, properly marked and carefully packed for detailed investigation.

Stratigraphy

In the area, the rock sequence is composed mainly of upper Cenozoic clastic sediments. The stratigarphic succession of the area is constituted of Upper Pegu Group and Irrawaddy Formation. The lithologies are dominated by sandstone, shale and clay, and conglomerate. The regional tectonic setting and lithostratonomic characteristics indicate the molasse nature of these sediments.

The sedimentary rocks in the area are subdivided into two formations based on the lithologic and faunal characteristics. They are

(2) Irrawaddy Formation (Late Miocene to Early Pleistocene)

(1) Obogon Formation (Middle Miocene)

The abundance of fossil woods is the distinguishing characteristic for Irrawaddy Formation. Furthermore, the remains of terrestrial and aquatic vertebrates are recovered from the sediments of this formation.

Obogon Formation

It is composed of alternations of mottled, blue gray clay with fine- to medium-grained sandstone. In the area, Obogon Formation occurs as inlier, surrounded by younger Irrawaddy Formation. However, the outcrop of Obogon Formation has been limited or poorly exposed and good exposures are found along the southern bank of Yin Chaung and Pagoda Hill (Phayagon) in Ondwe Village. The lower boundary of Obogon Formation with underlying Kyaukkok Formation is not observed in the area. The contact with overlying Irrawaddy Formation is indicated by gradual lithologic changes from fined grained, thin bedded sandstone to yellowish brown, massive pebbly

sandstone of Irrawaddy Formation. According to the lithology, stratigraphy and faunal assemblage, Obogon Formation of Yinseik area may belong to the Middle Miocene in age.

Figure 3 Light gray clay at the lower part of Obogon Formation

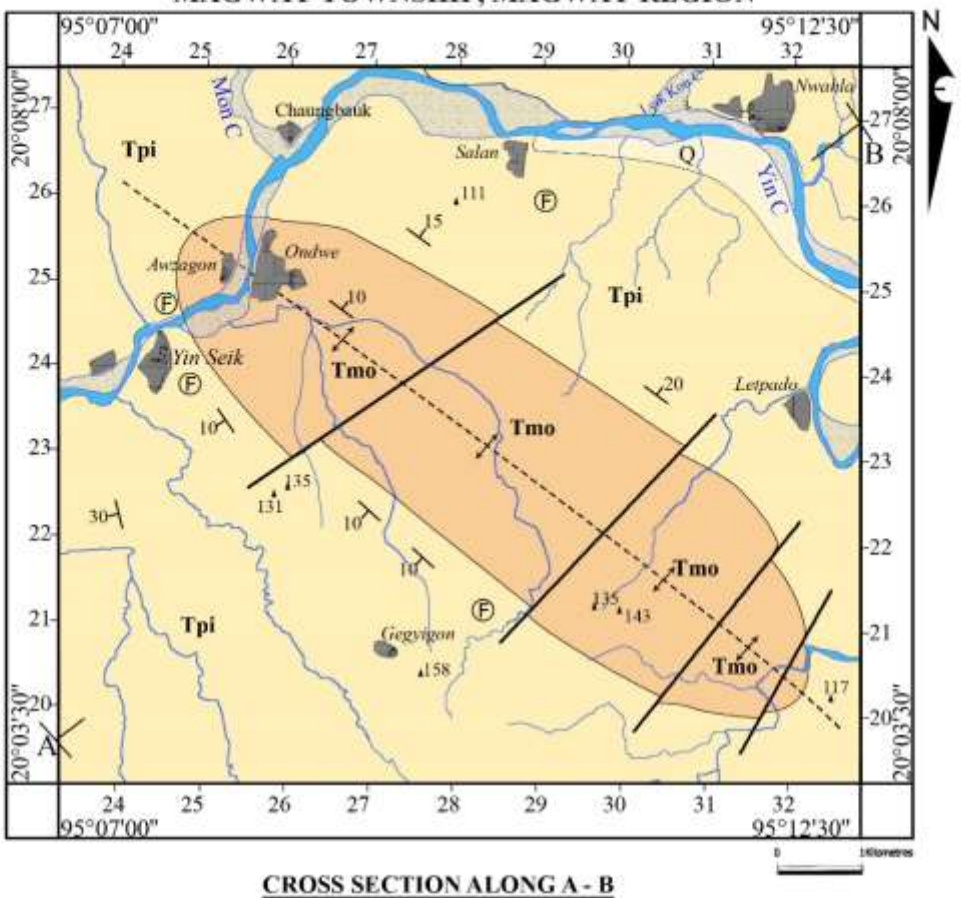
Figure 4 Fossiliferous hard sandstone band intercalated with buff colored, poorly indurated sandstone of Obogon Formation
(Loc: 20˚06'43" N; 95˚08'31" E)

Irrawaddy Formation

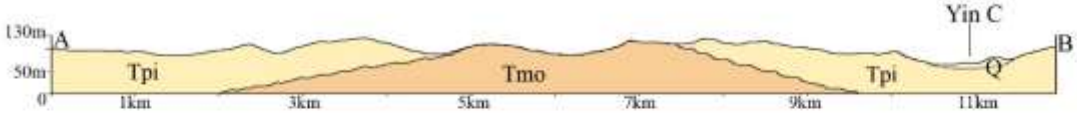
Irrawaddy Formation is characterized by the abundance of fossil wood and yielding of vertebrate fossils. Irrawaddy Formation is widely exposed on both north eastern and south western flanks of Ondwe Uplift as the low lying where the dips gently dipping to north east and south west respectively. Good exposure of this formation can be observed along the road section of Magway-Taungdwin road and in the vicinity of Yin Chaung bridge. Irrawaddy Formation unconformably overlies Obogon Formation in the area. The middle to late Pleistocene River Terraces deposits unconformably overlie on this formation. Several genera of vertebrates (Primate, Carnivora, Perissodactyla and Artiodactyla) have been documented from Irrawaddy Formation exposed in Yinseik area (Jaegear et al., 2011). This faunal assemblage generally suggests Late Miocene age for the sediments of Irrawaddy Formation.

Figure 5 Left. Medium to thick bedded, horizontally laminated, concretionary sandstone & Right. Large scale planar type cross bedding in medium to thick bedded sandstone of Irrawaddy Formation
(Loc: 20˚06' 38" N; 95˚08'40" E)

GEOLOGICAL MAP OF THE YINSEIK AREA, MAGWAY TOWNSHIP, MAGWAY REGION



CROSS SECTION ALONG A - B



EXPLANATION

Age	Symbol	Formation	Lithology
PLEISTOCENE	Q	Alluvium	
EARLY PLEISTOCENE	Tpi	Irrawaddy Formation	Light grey-to whitish, massive, friable micaceous sandstone with subordinate massive clay to silty clay
		Unconformity	
MIDDLE MIOCENE	Tmo	Obogon Formation	Yellowish brown-to buff coloured, fine to medium-grained, thin-bedded sandstone

GEOGRAPHICAL SYMBOLS

Stream
Village
Spot high

GEOLOGICAL SYMBOLS

Dip and Strike
Lithologic Contact
Fault
Fossil locality
Anticlinal axis

Vertebrate Paleontology

Vertebrate fossils from Irrawaddy Formation exposed in Yinseik area have been poorly known although geological survey had been taken place due to its hydrocarbon prospect in this area. Bender (1983) reported the dental remains of *Stegolophodon* from the Irrawaddy Formation. Chavasseau (2009) reported the remains of extinct perissodactyla (Chalicotheriidae) from the Irrawaddian sediments of present area. Jaeger et al., (2011) described the discovery of hominoid (*Khoratpithcus* sp.) and other vertebrate remains from Irrawaddy Formation exposed in Yinseik area.

To date, 13 families and 16 genera of vertebrate fossils have been documented from the Yinseik area (Table 1). However, due to the fragmentary nature of the specimens, it is difficult to indentify some specimens to appropriate genus or species level. Thus, these specimens are referred to genus and species indeterminate (gen et sp. indet.) or conferred genus. The present work carried out the systematic paleontology of crocodile remains recovered from Yinseik area.

The recovered specimens include gnathic materials as well as skeletal materials. The taxonomic assignments to generic/species level are based mainly on the dento-gnathic materials which are the most reliable for taxonomic comparison. All fossil materials used in this work are deposited in University of Magway. Taxonomic system mainly follows those of Carrol (1998) and Mc Kenna and Bell (1997).

Institutional Abbreviation. MGW-YSK, Magway University-Yinseik

Table 1 Vertebrate Fossils from Irrawaddy Formation of Yinseik area, Magway Township (after Jaeger et al., 2011), * represents the specimens studied in present work

PRIMATE
Hominidae
Khoratpithecus ayeyarwadyensis
PROBOSCIDEA
Stegodontidae
Stegolophodon sp.
ARTIODACTYLA
Suidae
Tetraconodon minor
cf. Hippopotamodon sivalense
Propotamocheorus hysudricus
Palaeochoeridae
Schizochoerus sp.
Tragulidae
Gen. et sp. indet. (medium-sized)
Bovidae
Antilopini indet.
Gen. et sp. indet.
Anthracotheriidae
Merycopotamus medioximus
CARNIVORA
Gen. et sp. indet.
PERISSODACTYLA
Rhinocerotidae
cf. *Rhinoceros*
Equidae
Hipparion sp.
Chalicotheriidae
Gen. et sp. indet.
CARCHARHINIFORME
Carcharhinidae
Glyphis pagoda
CROCODILIA
Gavialidae
**Gavialis* sp.

Systematic Paleontology

Order Crocodilia Gmelin 1789

Superfamily Gavialoidea Hay 1930

Family Gavialidae Hay 1930

Genus Gavialis Oppel 1811

Gavialis sp.

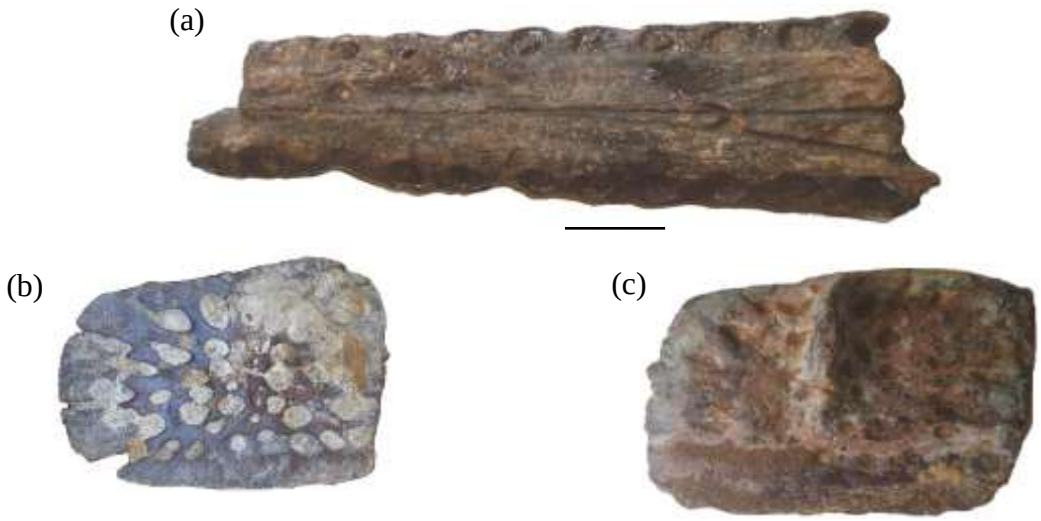


Figure 6 *Gavialis* sp. (a) MGW-YSK 1, mandibular fragment (b) MGW-YSK 2, bony plate, Osteoderm (c) MGW-YSK 3, bony plate, Osteoderm

Material: MGW-YSK 4, mandibular fragment

Locality: southwest of Salan Village (20º 07' 30" N, 99º 09' 58" E)

Horizon and Age: Lower Irrawaddy Formation, Late Miocene

Description: The **mandibles (MGW-YSK 1)** show longitudinal furrows on the ventral surface. The morphology of the dentary reflects that of maxilla in being flat and tubular along most of its length and then spatulate in its anterior portion, comprising the first two alveoli. The anterior most region of the dentary is not preserved. For most of its length, the dentary is perfectly straight. The present fragmentary dentary contains 20 to possibly 22 alveoli, as suggested by the presence of a rugose bony infilling within the last alveolus.

Osteoderms (MGW-YSK 2 & YSK 3) are square and the majorities of them are rectangular, being wider than long (Fig 6) and flat to slightly convex. They are relatively thin and bear only a few relatively large pits on their dorsal surface. A short median keel is present on the dorsal surface, which does not spread anteriorly or posteriorly. The edges of these osteoderms are irregular, bearing small spiny outgrowths possibly indicating the presence of a suture. The ventral surface shows striae for epaxial muscle attachments as well as one or two relatively large foramina per osteoderm.

Comment: The genus *Gavialis* comprises a single living species, G. *gangeticus* which today is restricted to the riverbanks of Bangladesh, India, Nepal and West Pakistan. The global wild gharial population is estimated at fewer than 235 individuals, which are threatened by loss of riverine habitat, depletion of fish resources, and entanglement in fishing nets. As the population has declined drastically in the past 70 years, this genus is listed as Critically Endangered on the IUCN

Red List. It is characterized by its extremely long, thin jaws, which are regarded as an adaptation to a primarily piscivorous diet (fish eating). The oldest fossil material allegedly referable to this genus has been recovered from the Miocene of Pakistan. *Gavialis* is abundant in continental Pleistocene deposits of the Indo-Pakistani region. The genus was also reported from the Pleistocene of Java, Myanmar and Thailand.

Paleoecology

From the Yinseik area, remains of the primate (*Khoratpithecus* sp.), carnivores, Anthracothere (*Merycopotamus* sp.), tragulid, wild boar (*Tetraconodon* sp. and *Propotamochoerus* sp.), bovids, rhinoceros (*Rhinoceros* sp.), horse (*Hipparion* sp.), elephant *(Stegolophodon* sp.) and crocodile (*Gavialis* sp.) occur in the sediments of Irrawaddy Formation. Among these animals, *Khoratpithecus* is a close relative of extant ape, Orangutan, and is as an arboreal whereas carnivores, tragulids, anthracothers, wild boar, bovids, rhinoceros and elephant are terrestrial mammals. The tragulids, wild boars, rhinoceroses and elephants might have been the habitants of forest/woodland as their living counterparts whereas the bovids might have roamed in the open grass land or on rolling hills as cattle of the present day.

The anthracotheres have long been considered to have habits and habitats similar with hippopotamus (Kron and Manning, 1998) and are likely to be a dependent of riverine environment. The crocodile might have preferred in the swamps or in the streams/rivers as present day's crocodiles do. The abundance of forest/woodland adapted animals in Yinseik area indicates the dominance of forested condition rather than grassland for these animals. Thus, these animals probably lived in the forest/woodland associated with riverine environment. The evidence for forested habitats in the present area by the early Late Miocene is further reinforced by the stable isotope analyses on extinct horse (*Hipparion*) teeth from the Yinseik area. These specimens yielded highly depleted $\delta^{18}O$ and $\delta^{13}C$ values suggesting the existence of closed and humid habitat in present area (Jaeger et al., 2010).

Present day environmental conditions in Central Myanmar are characterized by a subtropical semi−arid climate especially in most parts of Mandalay and Magway Region. The vegetation of this region is dominated by open shrub lands and grasslands. Therefore, the occurrence of forest dwelling mammals in research area contributes to the implication that the Late Miocene paleoenvironment of the Yinseik area was drastically different from the present day's conditions in Central Myanmar.

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