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# A FOSSIL MIOCENE WHALE FROM THE TIPAM SANDSTONE, ST. MARTIN'S ISLAND, BANGLADESH

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**Abstract :** The first vertebrate fossil, a lumbar vertebra from a mysticete whale, known from the Tipam Sandstone of the Bengal Basin is presented and described. Large mysticete remains from Miocene deposits surrounding the Indian Ocean are exceedingly rare, making this specimen, while isolated, important for discussions of cetacean evolution and biogeography, as well as for understanding the geologic context of St. Martin's Island. Miocene Asian Cetacea are known from fragmentary material, requiring the reduction of two nominal taxa, *Mioceta bigelowi* and *Mioceta magna*, to *nomina dubia*.

*Key words : Mysticeti, cetacean, Tipam Formation, Bengal Basin*

**Résumé :** Le premier fossile de vertébré, une vertèbre lombaire d'une baleine mysticète, provenant de la formation de grès du Tipam dans le bassin du Bengale, est présenté et décrit. Les restes de grands mysticètes issus de dépôts du Miocène encerclant l'Océan Indien sont excessivement rares, faisant de ce spécimen, bien qu'il soit isolé, une découverte importante pour les discussions portant sur l'évolution et la biogéographie des cétacés, ainsi que pour l'étude du contexte géologique de l'Ile de Saint-Martin. Les cétacés asiatiques datant du Miocène sont connus sous forme de restes fragmentaires, impliquant la réduction de deux noms taxonomiques, *Mioceta bigelowi* et *Mioceta magna*, en *nomina dubia*.

*Mots clés : Mysticeti, cétacé, Formation du Tipam, Bassin du Bengale*

## INTRODUCTION

St. Martin's Island, known locally as Narikel Jinjira, lies in the northeastern part of the Bay of Bengal, 13 km from southernmost Bangladesh and 10 km from the Burmese coast (20°34'-20°39' N and 90°18'-92°21' E; Fig. 1). It has an area of approximately 8 $km^2$, depending on the tide (Hassan & Ahmed, 1996), with a maximum elevation of about 6.5 m.

The island is the eastern leg and part of the hinge of an anticline and represents the westernmost extent of the Arakan Yoma uplift (Islam, 1980). It is ringed by a boulder field in the intertidal zone, especially prominent along the southern and western shores (Khan, 1964; Islam, 1980). The boulders are of two lithologic types: erratics of resistant bedrock that collapsed after being undercut, and spherical calcareous concretions.

During a survey of coral structures on the island in the fall of 1996, Dr. Tom Tomascik of Dalhousie University and Mr. Saiful Alam Paiker of SEA-NJ (a local non-governmental organization) found a cetacean vertebra within a concretion approximately 1 m in diameter from the southeastern intertidal zone near the southernmost tip of the island. This is the first record of a fossil whale from the Bengal region, and merits description. In this paper we provide a review of the geology of the island and a description of the fossil.

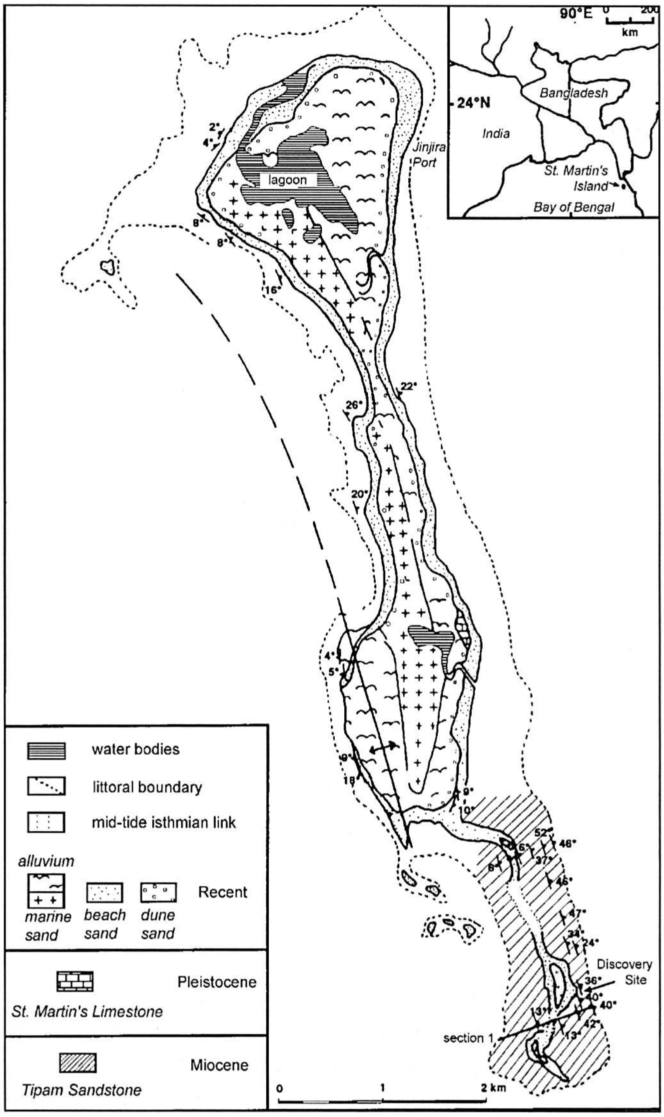


FIGURE 1. Geology and geography of St. Martin's Island, Bangladesh. Stratigraphic succession follows Islam (1980). Modified from Islam (1980).

## GEOLOGIC CONTEXT

The vertebra was found embedded within a medium- to fine-grained gray quartz sandstone. A thin section made from the surrounding matrix reveals it to consist of fine-grained, well-sorted, angular quartz clasts, and a minor content of glauconite, micas, marine shells (gastropods and bivalves), and plagioclase feldspar in various states of alteration, cemented by calcite. According to Khan (1991), the Tipam Sandstone is a medium- to very coarse-grained sandstone easily identifiable across Bangladesh by its feldspar content, which is consistent with the thin section. The angular clasts and presence of feldspar suggest a nearby source for the sediments, but the somewhat smaller than typical (for the Tipam Sandstone) clasts and presence of glauconite imply that they have been transported further offshore than the type locality's depositional facies (Wadia, 1976).

Review of the literature reveals inconsistency in the exact identity and age of the beds of St. Martin's Island. Khan (1964) correlated them with the Tipam Group. Khan (1991) placed them more specifically within the uppermost member of the Tipam Group, the Girujan Clay, describing the island as composed of «a shale interbedded with fossiliferous sandstone» (Khan, 1964: p. 5), although no measurements were presented. This identification has been followed by many subsequent authors (e.g. Akhtar, 1992; Hassan & Ahmed, 1996).

Islam (1980), however, presented two measured sections in the southern portion of the island near the discovery locality. Islam described a sandstone with minor interbedded shales and silty sandstones. Of the over 160 meters of described section, only a total of 44 meters were described as shales or sandy siltstones, representing only 27 percent of the total section. Islam preferred the Tipam Sandstone identification. Considering the large extent of sandstones (and relative absence of shales) found in the southern portion of the island, this identification is tentatively accepted.

Published ages for the Tipam Sandstone range from the early (Raju & Mathur, 1995), late early (Banerji, 1984), middle (Khan, 1991), and late Miocene (Alam, 1989), to early Pliocene (Akhtar, 1992): nearly 20 million years of uncertainty. Akhtar (1992) examined pollen from a shale subunit on St. Martin's Island and found an assemblage typical of Tertiary age and similar to those found elsewhere in the Bengal Basin (e.g., the Miocene Lower Siwalik Formation). However, Akhtar decided upon a Pliocene age instead of Miocene due to the «well-preserved» condition of the grains. Because quality of preservation is only loosely correlated with age we prefer to retain a Miocene age pending further study.

## SYSTEMATIC PALEONTOLOGY

Class MAMMALIA Linnaeus, 1758
Order CETACEA Brisson, 1762
Suborder MYSTICETI Flower, 1864
Family CETOTHERIIDAE?
(Brandt, 1872) Miller, 1923

### *Specimen*

McGill University Redpath Museum (RM) 20.5363, an isolated vertebral centrum (Fig. 2).

### *Description*

The vertebral centrum is elongate, virtually cylindrical, with relatively flat anterior and posterior epiphyses (Figs. 2.3, 2.4). In dorsal view, two oval fossae are medial to the bases of the pedicles of the neural arch (Fig. 2.1). Their depths are exaggerated due to dissolution. Similar fossae have been described in the lumbar vertebrae of the Eocene mesonychid *Pachyaena ossifraga* Cope, 1874 (Zhou *et al.*, 1992). The ventral surface is eroded, but a trace of a median ridge can still be seen. Principal measurements are given in Table 1.

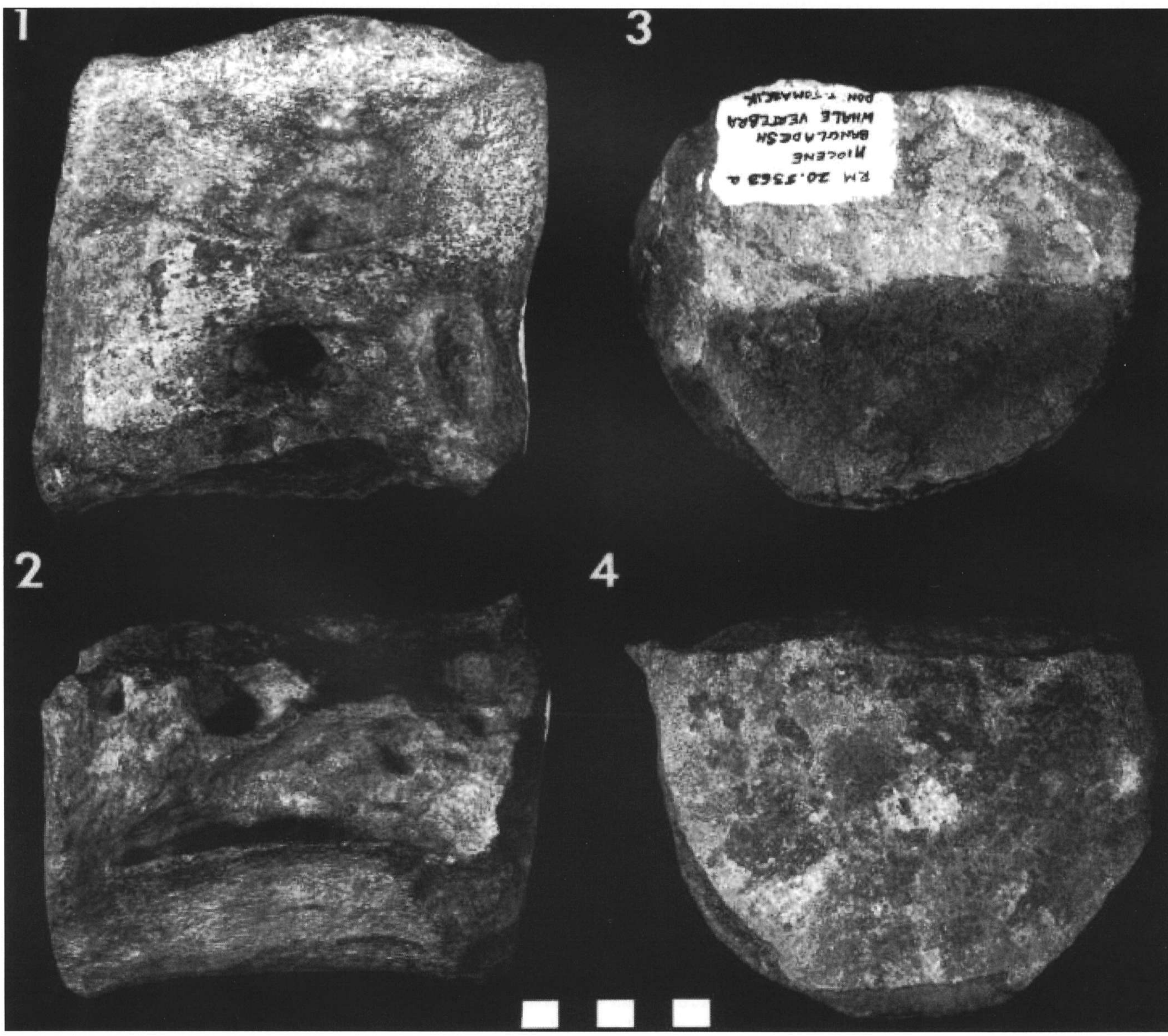


FIGURE 2. Lumbar Vertebra of mysticete whale (Cetotheriidae?) from the Miocene Tipam Sandstone (Tipam Group) of St. Martin's Island, Bangladesh (RM 20.5363). (1) Dorsal and (2) lateral views. Notice the deep concavities due to dissolution. (3 & 4) Cranial and caudal views.

A portion of a neural arch pedicle is preserved, as well as part of one transverse process, inflected dorsally, probably due to distortion. It has undergone lateral shear so that the bilateral symmetry seen in dorso-ventral views is distorted. Few of the edges of the bone are unbroken so measurements underestimate the original size. Some of the bone has been dissolved, especially the lateral surface seen in Figure 2.2.

This vertebra is identified as belonging to a cetacean because of its large size and the cylindrical shape of its centrum. Some Late Miocene fossil dugongid Sirenia and Pliocene, Pleistocene, and Recent Steller's sea cows (*Hydrodamalis* spp.) are known to approach this size, but their lumbar vertebrae have relatively shorter centra that are not so cylindrical in cross section (Domning, 1978). Rather their vertebral centra are flat dorsally where they floor the neural canal, and are prolonged ventrally at the mid-point.

The specimen can be identified more specifically as belonging to a mysticete whale based on the elongate, cylindrical form of the vertebral centrum, typical of lumbar vertebrae of Mysticeti. Some fossil and Recent sperm whales (family Physeteridae) approach the size of this vertebra, but in physeterids the vertebral centrum is relatively shorter anteroposteriorly, and is not so nearly cylindrical in cross section.

## DISCUSSION

Mysticete whales are known from latest Eocene (Mitchell, 1989) to Recent time, and are virtually cosmopolitan in their distribution, being found both in the past and present from arctic to equatorial latitudes (Fordyce & Barnes, 1994; Fordyce *et al.*, 1995). Their fossils are known from all ocean basins, having been found in appropriate-age sediments on all continents of the earth (Fordyce & Barnes, 1994), including Antarctica (Mitchell, 1989). The specimen at hand is, therefore, not unexpected from the Indian Ocean realm, yet the paucity of other fossil cetacean remains of any type in Southeast Asia, or around the Indian Ocean, make this discovery significant (as well as an oddity).

Most of the earliest Mysticeti of Eocene and Oligocene time, with the notable exception of the very large latest Eocene tooth-bearing mysticete, *Llanocetus* Mitchell, 1989, were relatively small by comparison with most other whales, most having had total body lengths in the size range of 3 to 4 m. In particular, the primitive Oligocene tooth-bearing Mysticeti of the family Aetiocetidae were exceptionally small mysticete whales, having skulls less than 1 m in length, and total body lengths, extrapolated from their skulls and a few rare partial skeletons, in the range between 3 and 4 m (Barnes *et al.,* 1995).

Few associated skeletons of the later Miocene mysticetes have been documented in the published literature, the nicely-preserved skeletons of Middle Miocene baleen-bearing Cetotheriidae from the Calvert Formation in Maryland and Virginia being notable exceptions (eg., Kellogg, 1968). Those skeletons of Middle Miocene Cetotheriidae that have been documented have skeletal structures and cranium-to-body ratios that are very similar to those of Recent rorquals of the family Balaenopteridae. The cetotheriids and balaenopterids are comparatively generalized baleen-bearing mysticetes, and these two groups are more closely related, one to another (sister taxa), than either is to the more highly derived right whales (Balaenidae and Neobalaenidae) and the gray whales (Eschrichtiidae) (see Barnes & McLeod, 1984).

The vertebra at hand is from a medium-sized mysticete. Its dimensions are only slightly larger than the lumbar vertebrae in the holotype skeleton of *Aglaocetus patulus* Kellogg, 1968, a Middle Miocene cetotheriid from the Calvert Formation. Fusion of the anterior and posterior vertebral epiphyses to the centrum indicate that it is from an adult individual. Epiphyseal fusion in cetacean vertebral columns commences at the anterior and posterior ends, and during ontogeny progresses toward the middle (= lumbar region). Because this is a lumbar vertebra with fused epiphyses, it is from a fully adult individual.

Baleen-bearing mysticetes of the extinct family Cetotheriidae are known from Oligocene to Pliocene time (Fordyce & Barnes, 1994), and the modern rorquals and related members of the family Balaenopteridae have a geochronological range from Late Miocene to Recent time (Barnes, 1977). Morphologically, the vertebra from Bangladesh could be either a large cetotheriid or a medium-sized balaenopterid. Its geologic age is at a time when cetotheriids were abundant and widespread and when balaenopterids were apparently originating. From a temporal perspective, therefore, the specimen most likely is a member of the family Cetotheriidae.

The holotype skull of the Middle Miocene cetotheriid *Aglaocetus patulus* Kellogg, 1968, is 1635 mm in length (Kellogg, 1968:168). In «typical» cetotheriids, as in Recent Balaenopteridae, the cranial length is usually approximately 20% of the total body length. Extrapolating from the dimensions of the holotype specimen of *A. patulus*, the vertebra from Bangladesh undoubtedly belonged to an animal whose cranial length was slightly greater than 1.7 m, and whose total body length (5 times the cranial length) was therefore approximately 8.5 m.

Increase in size among baleen-bearing mysticete whales was a phenomenon of Miocene and later time (Fordyce and Barnes, 1994), with the largest known species being among the living taxa of Mysticeti. The vertebra from Bangladesh is from an animal whose size is typical of the larger species of Mysticeti that have been reported from sediments of Middle Miocene age. Assuming that, as is the case with living whales, the larger Mysticeti in the geologic past were highly mobile, and were capable of migrating great distances across the oceans, this specimen might have represented a cosmopolitan species.

Other Miocene Cetacea have been reported previously from the Indian Ocean region (Deraniyagala, 1967, 1969). These fossils, from Sri Lanka, are of great interest biogeographically, and because they include some well-preserved bones; these records indicate that future work might reveal relatively complete specimens from the same area. Unfortunately, some of these specimens, namely isolated vertebrae and ribs of mysticetes, have been proposed as holotypes for new taxa.

Deraniyagala (1967) has named the reputed cetotheriid *Mioceta bigelowi*, from the Miocene «Malu Deposit» in Sri Lanka, establishing as the holotype of the species a cervical vertebra. This (1967) reference in which the binomen first appears is an abstract, and technically the taxon is introduced in that publication as a *nomen nudum*. The holotype cervical vertebra was later (Deraniyagala, 1969) more fully described and illustrated, and two additional vertebrae, a thoracic and a lumbar, were assigned to the same species by Deraniyagala. From the same deposit he named another, larger species of cetacean, *Mioceta magna* Deraniyagala, 1969, based on two rib fragments of two different individuals. Objectively, these holotype and referred specimens are non-diagnostic skeletal elements, and in the interests of clarifying the systematics of fossil cetaceans (e.g., Barnes, 1977), *Mioceta bigelowi* and *Mioceta magna* must each be declared a *nomen dubium.*

This is the first vertebrate fossil recovered from the Tipam Sandstone. Previously reported fossils were invertebrates and plant material from the more northern and ostensibly more nearshore facies of the formation (Khan, 1964; Awasthi and Mehrotra, 1989; Prakash *et al.*, 1994). Presence of cetaceans and matrix mineralogy confirm a marine depositional environment for the St. Martin's sediments, and corroborate Alam's (1989) interpretation of a shelf molasse sedimentary origin of the Tipam Sandstone, although more distal shelf deposition than seen in more northerly exposures of the formation.

Boulder fields similar to that found on the coast of St. Martin's Island are known along the coast of mainland Bangladesh (Ashfaque, 1967; Siddiqi, 1967; Rizvi, 1969). Thus, the concretions of the Tipam Sandstone may represent a new window to the near-shore marine fauna of the Miocene of Asia.

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TABLE 1. Measurements (in mm) of cetacean vertebra (RM 20.5363) from St. Martin's Island, Bangladesh. Measurements of the vertebral articular surfaces were made at either end, to avoid the most weathered areas.

| | |
|---|---|
| Length of centrum | 126 |
| Height of centrum | 90 |
| Width of centrum | 108 |
| Maximum width of articular surface | 125 |
| Maximum height of articular surface | 106 |