Proboscidean Fossil from the Tha Chang Sand Pits, Nakhon Ratchasima Province, Thailand

Yupa Thasod[1,*], Pratueng Jintasakul[2], Benjavun Ratanasthien[3]

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Abstract

Proboscidean fossils were found in sand pits Nakhon Ratchasima province, northeastern Thailand. The important materials used for classification in this study were teeth. The structures, size, and character of teeth were recognized in details. They were classified into eight genera in four families. Family Dienotheriidae includes *Prodeinotherium pentapotamiae*, Family Gomphotheriidae includes *Gomphotherium* sp., *Tetralophodon* sp., *Sinomastodon* sp., and cf. *Protanancus macinnesi*, Family Stegodontidae includes *Stegolophodon* sp., and *Stegodon* sp., and Family Elephantiidae includes *Elephas* sp. The age of these fossils ranges from Middle Miocene to Pleistocene.

Keywords: Proboscidean fossil, Tha Chang sand pit, Nakhon Ratchasima, Thailand

Introduction

In the Northeastern Thailand, Proboscidean fossils have been found in Tha Chang sand pits in Chaloem Phra Kiat District of Nakhon Ratchasima Province since 1985. The fossils have been uncovered during sand mining operations near the Mun River (Figure 1). A private enterprise opened an area of 80 to 160 square kilometers and mined sand to depths of 20 to 40 meters. Animal fossils and wood remains were found at depths below about 5 meters (Figure 2). A large number of mammalian fossils, especially proboscidean fossils, were collected by Mr. Somsak Srihataphadungkid, the sand pit's owner. Some of these fossils were later given, upon request, to the Department of Mineral Resources. One of us, Dr. Pratueng Jintasakul, a lecturer of the Nakhon Ratchasima Rajabhat University (NRRU), has collected fossil skeletons and keeps them in an exhibition room of the university (previous name is Rajabhat Institute Nakhon Ratchasima (RIN)). As the sand pit operations have gone deeper, more and more fossils have been uncovered and collected by amateurs. At present, almost fossil specimens are housed and exhibited in the Northeastern Research Institute of Petrified Wood and Mineral Resources, which honors His Majesty the King, Nakhon Ratchasima Rajabhat University, 1999 A.D and Sirindhorn Museum, Kalasin Province.

The mammalian fossils from Tha Chang sand pits were divided into three ages: Middle Miocene, Late Miocene to Early Pliocene, and Early Pleistocene. The Middle Miocene mammalian fauna consists of amebelodontid gomphothere, *Gomphotherium*, and *Prodeinotherium*. The Late Miocene to Early Pliocene fauna includes *Hipparion*, primitive *Stegodon*, *Stegolophodon*, and primitive *Merycopotamus*. The Early Pleistocene fauna includes advanced *Stegodon*,[1,2] Additionally, a new species of Uran-utang, *Khoratpitacus piriyai*[3,4] and a new species, *Merycopothemus thachangensis*[5,6] were

[1,3] *Department of Geological Sciences, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand 50200*

[2] *Northeastern Research Institute of Petrified Wood and Mineral Resources, Nakhon Ratchasima Rajabhat University*

* *corresponding author : e-mail address: yupa.t@cmu.ac.th; thasod@yahoo.com*

reported. The fossil indicated the late Miocene age. Thasod and Ratanasthien[7] reported a new species of *Sinomastodon*. They proposed that this *Sinomastodon* in this locality is more advanced than *Sinomastodon intermedius* from Pliocene age in China. Saegusa[8] was grouped Stegodontids in Asian including the Stegodontid from Tha Chang sand pits into many group by using the tooth morphology, however, the details of any genus are not included. The proboscidean fossils in this locality were study by Thasod[9]. Seven genera were reported including *Prodeinotherium petapotamiae*, cf. *Protanancus* cf. *macinnesi*, *Gomphotherium*, *Sinomastodon*, *Stegolophodon*, *Stegodon*, and *Elephas*.

This paper will summarize the previously study and new finding specimens on proboscidean fossils from "Tha Chang sand pits", in Chaloem Phra Kiat District, Nakhon Ratchasima Province, Thailand.

Abbreviation

NRRU, Nakhon Ratchasima Rajabhat University; **RIN**, Rajabhat Institute Nakhon Ratchasima (former name of Nakhon Ratchasima Rajabhat University); **NRRU-PRY**, Fossil is donated by Mr. Piriya Watchajitpan and housed in Northeastern Research Institute of Petrified Wood and Mineral Resources, Nakhon Ratchasima Rajabhat University.

Dental terminology of proboscidean teeth

The basic structure of a proboscidean tooth was gained from a rather primitive genus, *Gomphotherium*. Lophs and lophids are cone-like elements, arranged in several transverse ridges in the upper molars and in the lower molars, respectively. On each loph(id) was separated by median sulcus into two half-loph(id)s, the lesser worn side is called "posttrite half-loph(id)", the stronger worn side is called "pretrite half-loph(id)". Every fully developed half-loph(id) has at least two small cones that are more or less distinctly separated. These elements were named "conelets" by Osborn[10]. Another typical characteristic of mastodont molars are the "conules" [10] . Number of loph(id) can be written in tooth formula such as X5X means the tooth contains 5 loph(id) plus anterior and posterior cingulum (X) (more details of tooth structure can see in Figure 3).

Dental abbreviation

M and **m**, Molars, **P** and **p**, Premolars, capital letters indicate upper molars and lower case letters indicate lower molars; **R**, Right side; **L**, Left side.

Systematic paleontology

Order Proboscidea Illiger, 1811[11]

Family Deinotheriidae Bonaparte, 1845[12]

Genus *Prodeinotherium* Ehik, 1930[13]

***Prodeinotherium pentapotamiae* Lydekker, 1876[14]**

These specimens were studied by Thasod[9] and were summarized here. Two mandibles of *Prodeinotherium* were found from the sand pit. RIN15 is a partial right mandible with m1-m3 (Figure 4a) and another is a right preserving p4-m3 (Figure 4b) which is now housed in Sirindhorn Museum, Kalasin Province. The molar structures of these specimens can be assigned to *Prodeinotherium*, based on molar structure characteristic, molars had two or three ridges, with very simple cusps; the enamel thickness is about 5 to 8 millimeters. The molar size of *Prodeinotherium* is significant smaller than *Deinotherium*. *Prodeinotherium* is recognized in three species in different geographic locations, *P. bavaricum* in Europe, *P. hobleyi* in Africa, and *P. pentapotamiae* and, perhaps, *P. orlovii*, in Asia[15].

The specimens here referred to *Prodeinotherium pentapotamia* from Tha Chang sand pits are more complete than those previously reported from the Pong basin in Thailand[16]. The size and teeth characters of Tha Chang's specimens are comparable with *P. hobleyi* from Africa[17], *P. pentapotamiae* from India[18] and *P. bavaricum* from Europe[19]. Identification of this genus can be made by using the structure on the third premolar. Unfortunately, none is preserved in Thai's specimens. Therefore, these specimens are here temporality referred to the same species with the Indian species, *Prodeinotherium pentapotamiae*.

Family Gomphotheriidae Hay, 1922[20]

Genus *Gomphotherium* Burmeister, 1837[21]

Gomphotherium was widespread in Asia and Europe during the early Miocene to late Miocene. It characters are three loph(id) on the intermediate molars, the last molars may have four loph(id) or more, mesoconelets are smaller than the main cone, present anterior and posterior central conule on the pretrite, and show trefoil figures on worn surface[22]. Thasod[9] reported large size *Gomphotherium*'s specimens (RIN 2 and RIN 353) (Figures 4c,d). The tapering of molar shape is distinct characters this may use for classified them to a new species. Another isolated M3 (PRY99) was found (Figure 4e). It has X4X formula, small size, strong anterior and posterior central conule, mesoconelet is smaller than the main cone. Because it is isolated, this specimen is left as *Gomphotherium* sp.

Family Uncertain

Genus *Tetralophodon* Falconer, 1857[23]

Specimens of *Tetralophodon* in this locality are quite rare. This genus is characterized by the intermediate molars showing X4X loph(id) formula but the last molars are variable from 5 to 7 loph(id). *Tetralophodon* was evolved from trilophodont gomphothere and still contain primitive structure. Mesoconelet in *Tetralophodon* is smaller than the main cone as in trilophodont gomphothere. These characters are useful for divided *Tetralophodon* and *Stegolophodon* molars. In Tha Chang locality, two specimens of *Tetralophodon* were recognized. A right intermediate molar (PRY56) contains X4X formula (Figure 5a) and a right Rm3 (PRY19) has X5X formula (Figure 5b). These two specimens showing mesoconelet that smaller than the main cone. Anterior and posterior central conules are distinct and trefoil figures are present on worn surfaces. These might indicated the occurrence of a *Tetralophodon* in this locality.

Tetralophodon is reported in the Chaing Muan coal mine, Phayao Province and was identified as *Tetralophodon* cf. *xiaolongtanensis*, a species also reported from Yunnan, China. The fossil indicates a late Miocene age for this locality[24]. However, the *Tetralophodon*'s molars from Tha Chang are not similar to the Chiang Muan *Tetralophodon*.

Genus *Sinomastodon* Tobien et al., 1986[25]

There are several molars of *Sinomastodon* were found from the sand pit. They contain the following characters: bunodont molars, brachyodont, with trilophodont intermediates, elephantiod mandible, without lower incisors[25,26].

Sinomastodon from this locality was classified into *Sinomastodon* cf. *yangziensis*[27] and advanced *Sinomastodon*[7,9]. Additional specimens were identified, two intermediate molars (PRY59 and PRY101) and a left m3 (PRY62) (Figures 5 c, d, e). The molar teeth of this genus differ from *Gomphotherium* by developing secondary trefoil.

Subfamily Amebelodontinae Barbour, 1927[28]

Genus *Protanancus* Arambourg, 1945[29]

A mandible with molars and several isolated teeth of Amebelodontinae were found. These specimens all display a small size, slim, high crown and narrow at the apex, trilophodont on the intermediate molar, dislocation of the pretrite and posttrite half-loph(id)s, and cement deposited in inter-valleys that are apomorphic characters of Amebelodontinae[29,30]. RIN 25 is a right mandible with m1-m3 (Figure 6a), showing the above mentioned characters. The tooth structures and size of the third molars (NM1-9 and NM1-17) (Figures 6c, d) are comparable to *Protanancus macinnesi*[31,30] from Makobo, Kenya. This species was in Africa during the Middle Miocene. However, there is no evidence of lower tusk preserved in the mandible[9]. A genus in Amebelodontinae must have flat or shovel lower tusks. The molar teeth of this genus differ from the Miocene *Gomphotherium* by developed secondary trefoil and strong enamel folding on the erupted tooth surfaces.

Family Stegodontidae Osborn, 1918[32]

Genus *Stegolophodon* Schlesinger, 1917[33]

The most plentiful of proboscidean fossils from Tha Chang sand pits are belong to primitive genus *Stegolophodon* and advance genus *Stegodon*. *Stegolophodon* is characterized by compose of four loph(id)s on the intermediate molars, distinct median sulcus, mesoconelet as large as the main cone, contain four to six conules in each loph(id), in primitive *Stegolophodon* had lower tusks. The *Stegolophodon* found from Tha Chang sand pit is larger size than the northern Thailand species such as *Stegolophodon nasaiensis* and *Sl. praelatidens* from the Early Miocene and Middle Miocene, repectively. The numerous specimens from Tha Chang are comparable to *Stegolophodon stegodontoides* (and its relate form) because of their size, even though there are different details of teeth morphology However, some specimens have more primitive and simple characters, such as the number of lower m3 being X5X in PRY15 (Figure 6a) and RIN 3 (Figure 6b). Even so, the number of lophs corresponds to *S. stegodontoides*. These were probably caused by individual variations or by differences in evolutionary stages. In our opinion, this species may be a subspecies or new species.

Additional, there is an intermediate morphological form between advanced *Stegolophodon* and primitive *Stegodon* was found. The specimen PRY103 is a right m3 showing X7X lophid formula. There are four conules in each lophid, strong posterior central conules, but median sulcus is not clear (Figure 6c). These features can found in both *Stegolophodon* and *Stegodon* third molars. Moreover, a new species of advanced *Stegolophodon* was proposed by Saegusa (Figure 6d). This species contains X7X lophid formula as in PRY103 but it is very large size and carry the posterior central conule on the posttrite side especially on the hint.

Genus *Stegodon* Falconer, 1857[23]

Stegodont is a group of elephant-like proboscideans that flourished during the Pliocene and Pleistocene in East and South Asia. The generic definition of *Stegodon* was revised by Saegusa[8], based on the synapomorphy of a monophyletic taxon as follows: intermediate molars carry five loph(id)s or more, no distinct central conule on lower third molar, no lower tusk, and mesial root of lower third molar supports two lophids. Several specimens of *Stegodon* were discovered from the sand pits. *Stegodon elephantoides* (Clift, 1828)[34], *S. insignis* (Falconer, 1846) and *S. orientalis* (Owen, 1870)[35], were classified.

***Stegodon elephantoides* (Clift, 1828)[34]**

The specimen number PRY 69 (Figure 6e) is a Lm3 contain nine complete ridges and talonid, with subdivided conule into five to eight small conelets, thin cement deposit in the posterior valleys. The character and number of lophid of PRY 69 is comparable to the lectotype of *Stegodon elephantoides*. This species first found from the Irrawaddy sediment, estimate age about in lower Pliocene[10]. More research by Takai[36], *Stegodon elephantoides* (primitive) was found in the Lower Irrawaddy Fauna; provide the age from late Miocene to late Pliocene.

***Stegodon insignis* Falconer, 1846**

The specimen number PRY 201 is comprise L and R M3 and a mandible with Rm3. The M3s have X10X ridge formula (Figure 6f); the lower m3 has X11X ridge formula (Figure 6g). Conules were subdivided into fine conelets, plentiful cement in valleys, fine and strong enamel folding. These characters comparable to *Stegodon insignis*, especially the m3 is similar to specimen number Amur. Mus.19859[10]. *Stegodon insignis* was first found at Siwalik hill. It was Upper Pliocene to Lower Pleistocene in age[10]. In Myanmar, a related form, *Stegodon insignis birmanicus*, was found from the Upper Irrawaddy, indicated the age of late Pliocene to early Pleistocene[36].

***Stegodon* cf. *orientalis* Owen, 1870[35]**

A part of skull with left and right M3 (NRRU1002-02) (Figure 6h) and an incomplete Lm3, RIN 14, (Figure 6i) of *Stegodon* cf. *orientalis* were collected from the sand pit. The number of loph(id), shape of teeth, fine and asymmetry enamel folding are characterized. *S. orientalis* differ from *S. insignis* by has less cement developed, and ridges are wider.

S. insignis has greater degree of hypsodonty and the curvature of the crowns of both the upper and lower teeth is more pronounced. This species was widespread during Pleistocene in China and Japan.

Family Elephantidae Gray, 1821[37]

Genus *Elephas* Linnaeus, 1758[38]

Elephas sp. indet.

Isolated incomplete tooth specimen of *Elephas* was found (RIN 10) (Figure 6j). There are 13 plates on the tooth, may not be the last molar. They were recognized by advanced tooth characters. The tooth is increase in lamellae or plate, packed more densely; valleys are covered by cement and high crown. These characters are differs from the advanced *Stegodon*. Enamel thickness in *Elephas* is about three millimeter, thinner than *Loxodonta* but thicker than *Mammuthus*.

Throughout its evolutionary history, *Loxodonta* has remained in Africa. *Elephas* apparently dispersed twice out of Africa, in the mid-Pliocene into Asia where it evolved as a lineage terminating in *Elephas maximus*, and in the late Pliocene into Asia and Europe as lineages now extinct[39]. *Mammuthus* migrated out of Africa in the late Pliocene and subsequently spread rapidly throughout Europe, Asia, and North America[40]. The last glaciation in the northern hemisphere coincided with the disappearance of *Elephas* from Africa and the extinction of *Elephas antiquus* and *Elephas falconeri* in Europe. The extinction of all remaining taxa of the Elephantidae, except for *Loxodonta africana* and *Elephas maximus*, occurred early in the Holocene[41,40].

Conclusion and discussion

The proboscidean fossils in this locality are include *Prodeinotherium* (*P. pentapotamiae)*, Amebelodontinae (cf. *Protanancus macinnensi*), *Gomphotherium* (*Gomphotherium* sp. and a new species), *Tetralophodon* sp., *Sinomastodon* (*Sinomastodon* cf. *yangziensis* and *Sinomastodon* n. sp), *Stegolophodon* (*Stegolophodon stegodontoides* (and related forms), *Stegolophodon* n.sp., and *Stegolophodon* intermediate forms*)*, *Stegodon* (*Stegodon elephantoides*, *Stegodon insignis*, *Stegodon* cf. *orientalis* and primitive form *Stegodon*) and *Elephas* sp. The fossil assemblage indicates the age from Middle Miocene to Pleistocene.

The proboscidean and other fossils in Tha Chang sand pits may not deposited *in situ*. The surfaces of fossils show cracked and abraded that indicate reworked, but many specimens are in complete condition suggesting they were transported in a short distance. The primitive forms were found in the lower part and the advanced forms were found in the upper parts of a fluvial deposit in channel and floodplain system of mobile channels[42,43]. However, the positions of all fossil material were not known. Nevertheless, the diversity and abundant of fossils in this locality suggested this area had been a big forest for feed many animals in previous time.

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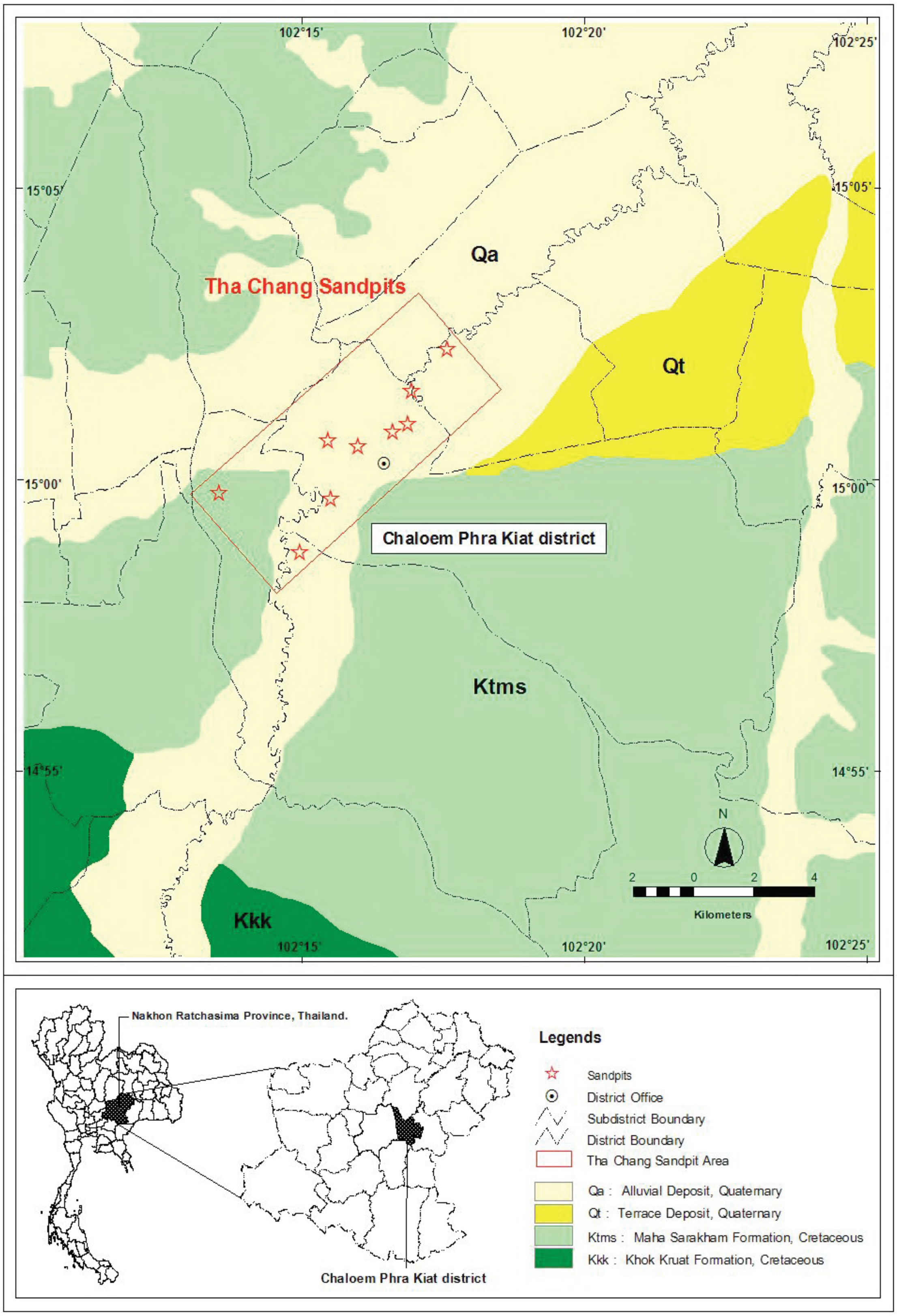

Figure 1 Map of fossil locality at Tha Chang sand pit, Chaloem Phra Kiat district, Nakhon Ratchasima Province (modified from Hintong et al., 1984; Yuyen and Sirinavin, 1985).

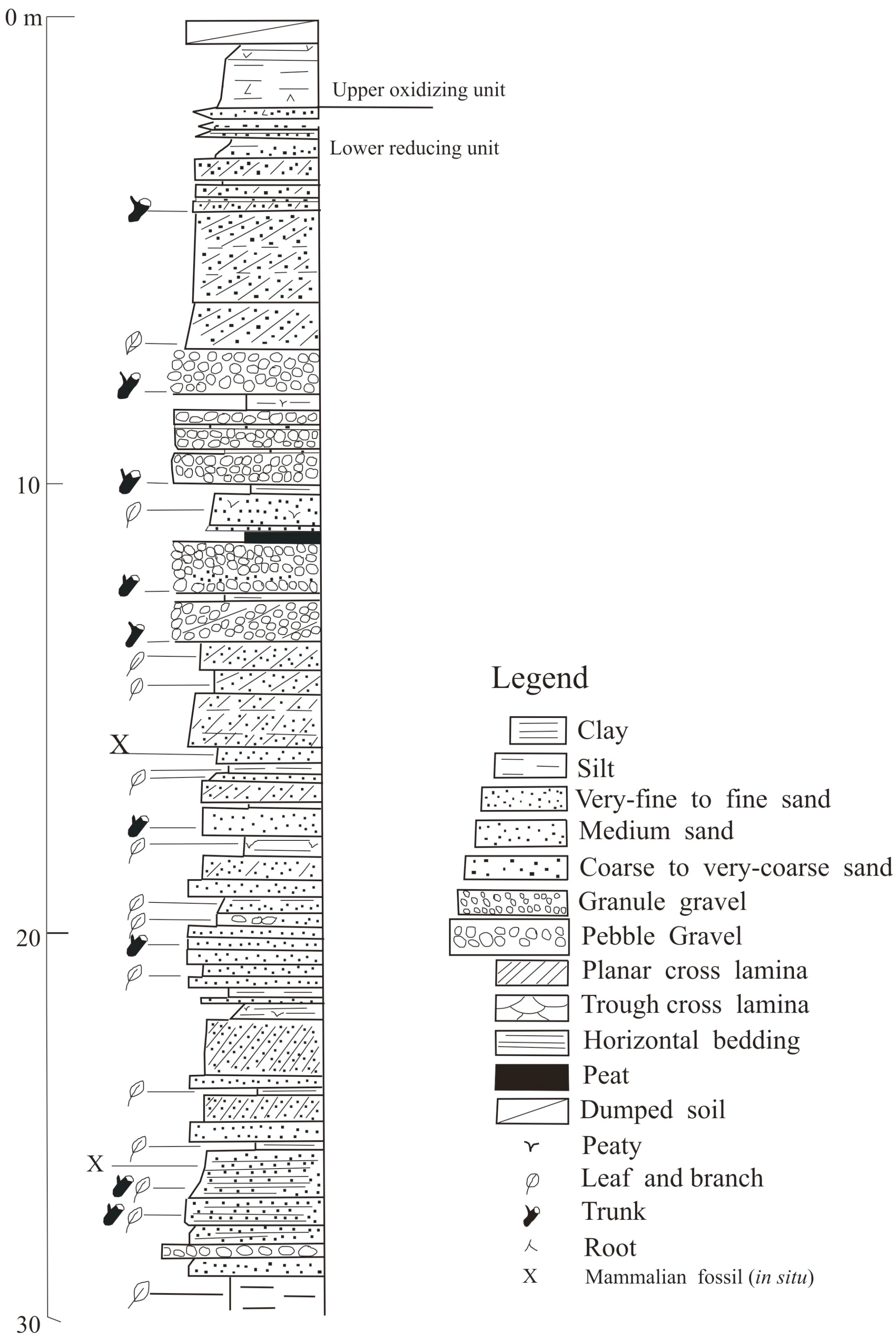

Figure 2 Stratigraphic succession of the Tha Chang sand pit No. 8[9].

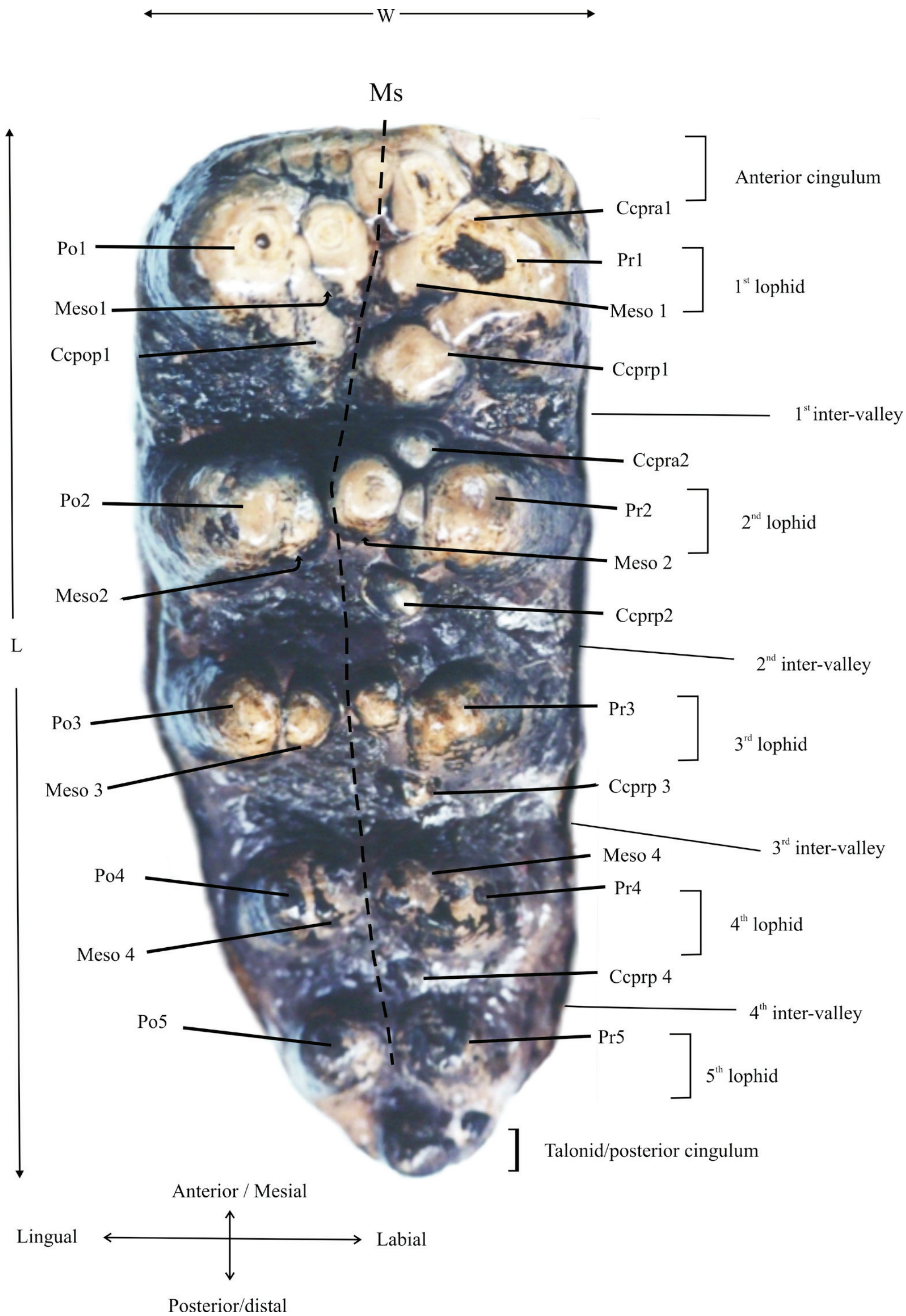

Figure 3 (a) Anatomical orientation, proboscidean dental nomenclature, and number of molar lophid of a right lower m3 of *Gomphotherium* having X5X tooth formula (modified from Tassy[44] and Thasod[9]). Key: Po1, 2, 3, 4, 5, 6, posttrite main cusp of 1st, 2nd, 3rd, 4th, 5th and 6th lophids; Pr1, 2, 3, 4, 5, 6, pretrite main cusp of 1st, 2nd, 3rd, 4th, 5th, and 6th lophids; Ccpop1,2,3,4, posterior posttrite central conule of 1st, 2nd, 3rd and 4th lophids; Ccprp1,2,3, 4, posterior pretrite central conule of 1st, 2nd, 3rd, and 4th lophids; Ccpra 1, 2, 3, anterior pretrite central conule of 1st, 2nd, and 3rd lophids, Meso, mesoconelet of each half-lophid, on both sides of median sulcus (adaxial cone), Ms, median sulcus[30], L, Maximum length, W, Maximum width.

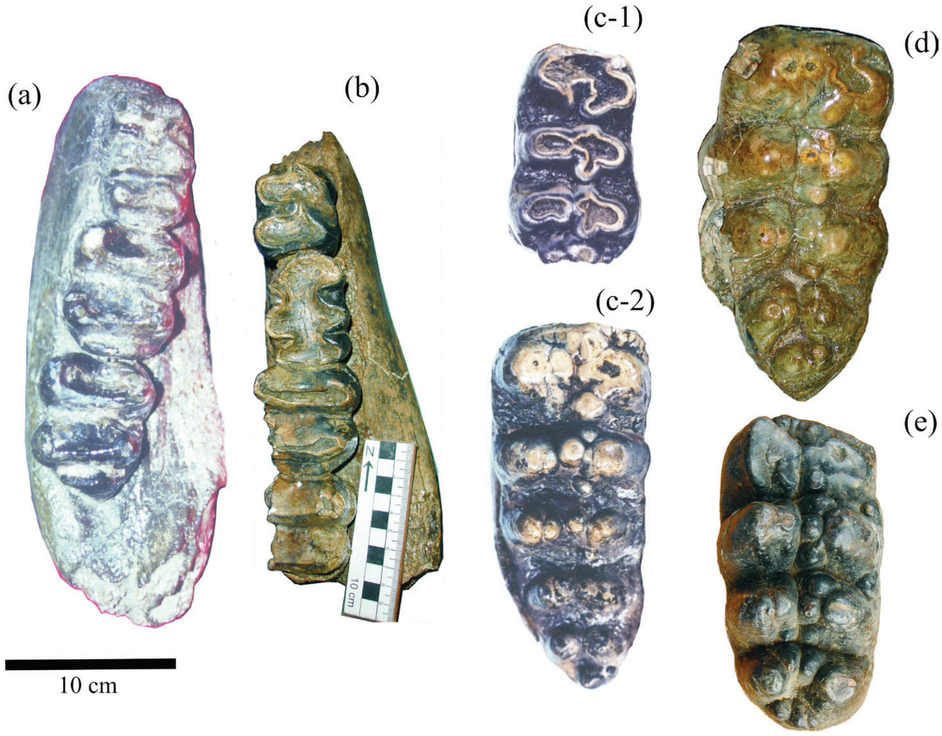

Figure 4 *Prodeinotherium pentapotamiae* (a) RIN15, right mandible with m1-m3, (b) KHO (at Sirindhorn Museum), a right mandible with p4-m3; *Gomphotherium* sp. (c) RIN2, right mandible with m2-m3, (d) RIN353, Rm3 (modified from Thasod[9]), and (e) PRY99, RM3.

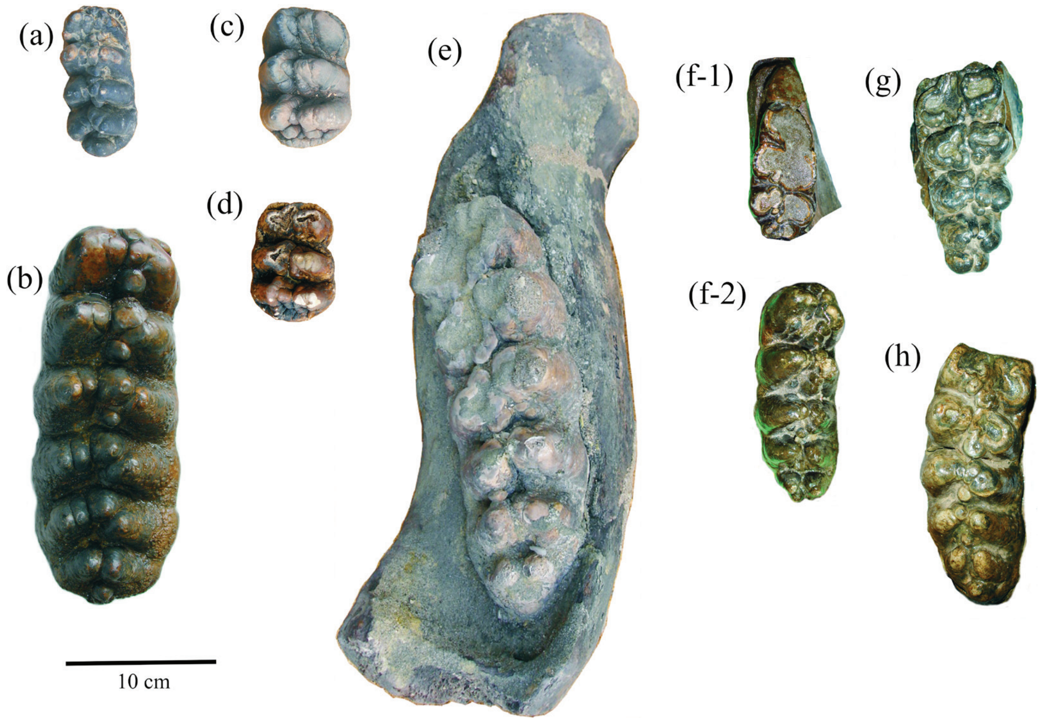

Figure 5 *Tetralophodon* sp. (a) PRY56, right intermediate molar (b) PRY19, Rm3; *Sinomastodon* sp. (c) PRY 59, intermediate molar, (d) PRY 101, intermediate molar, (e) PRY62, left mandible with m3; cf. *Protanancus macinnesi* (f) RIN25,Rm2 and Rm3, (g) NM1-9, LM3 (h) NM1-17, Rm3 (modified from Thasod[9]).

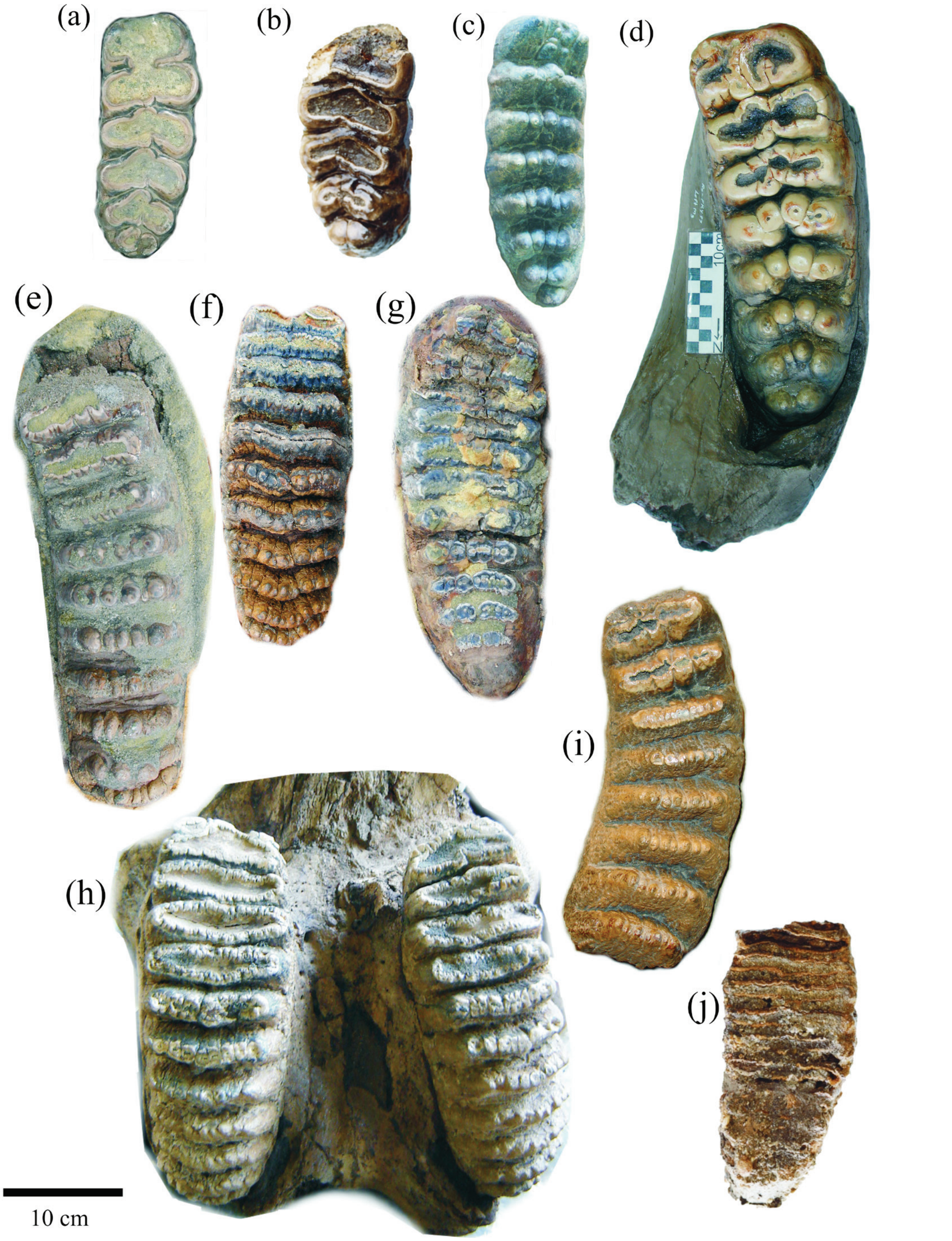

Figure 6 Stegolophodon cf. stegodontoides (a) PRY15, Lm3 (b) RIN3, Rm3; Stegolophodon intermediate form (c) PRY103, Rm3; Stegolophodon n.sp. (d) NRRU-PRY98 (cast), Lm3; Stegodon elephantoides (e) PRY69, Lm3; Stegodon insignis (f) PRY201, RM3; (g) PRY201, Lm3; Stegodon cf. orientalis (h) NRRU1002-02, Left and Right M3 (i) RIN14, Lm3; Elephas sp. (j) RIN10.