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查谟-克什米尔地区查谟后西瓦立克沉积中的亚洲象化石

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摘要：描述了一件象属（*Elephas*）的右上臼齿化石。标本产自查谟紧靠上西瓦立克亚群巨砾岩组（Boulder Conglomerate Formation）之上的砂质、粉砂质泥岩夹砾石层中，化石地点位于查谟市南10 km，Kharian村北约500 m处。根据齿板数、齿脊频率、釉质层厚度、冠高指数、绝对大小和齿长/齿高指数等牙齿形态参数，暂时将之归为 *Elephas* cf. *E. maximus indicus*。还简短讨论了象属的地理分布和地质时代。

关键词：查谟；中更新世；后西瓦立克沉积；哺乳动物纲，象科，*Elephas* cf. *E. maximus indicus*

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ELEPHAS CF. *E. MAXIMUS INDICUS* (ELEPHANTIDAE, MAMMALIA) FROM THE POST SIWALIK DEPOSITS OF JAMMU PROVINCE, JAMMU AND KASHMIR, INDIA

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Abstract　An upper right molar of *Elephas* is described from the sandy-silty mudstone containing small pebbles immediately overlying the Boulder Conglomerate Formation of the Upper Siwalik Subgroup of Jammu, exposed 500 m north of Kharian village and 10 km south of Jammu city. Based on the dental morphological parameters including plate number, lamellar frequency, enamel thickness, hypsodonty index, absolute size, length/width index it is tentatively referred to *Elephas* cf. *E. maximus indicus*. A brief discussion on distribution and age of this *Elephas* is also presented.

Key words　Jammu, India; Middle Pleistocene; Post Siwalik deposits; *Elephas* cf. *E. maximus indicus*, Elephantidae, Mammalia

1　Introduction

Elephantidae is a family of Proboscidea represented by over a dozen genera. Of these, eleven genera (*Primelephas*, *Mammuthus*, *Stegotetrabeldon*, *Stegodibeldon*, *Stegodon*, *Anancus*, *Morrillia*, *Tetralophodon*, *Paratetralophodon*, *Stegomastodon* and *Cuvieronius*) are extinct. Only a few species of *Elephas* and *Loxodonta* survive today. *Elephas* is represented by the living Asiatic elephants (*Elephas maximus bengalensis*-Indian elephant, *E. m. maximus*-Ceylon elephant, *E. m. sumatranus*-Sumatran elephant, *E. m. hirsutes*-Malayan elephant), and *Loxodonta*

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is represented by living African elephants (*Loxodonta africana oxyotis*-African steppe elephant, *L. a. cyclotis*-Bush or forest elephant, *L. a. africana*-Cape elephant). The molar morphological parameters of *Mammuthus primigenius* (extinct woolly mammoth) and *Elephas maximus* are very similar. Many paleontologists believe that the relationship between the woolly mammoth (*Mammuthus primigenius*) and the Indian elephant (*Elephas maximus*) was close and some also believe that they share 95% DNA, although the recent DNA study by Noro et al. (1998) suggests that *Mammuthus primigenius* and *Loxodonta* are more closely related to each other than either is to *Elephas maximus*. Sequencing the nuclear genome of the extinct woolly mammoth in detail has been described by Miller et al. (2008). A detailed study of *Elephas maximus* including diagnostic features, general characters, distribution, fossil record, form, function of skin, ontogeny and reproduction, ecology, behavior and genetics has been presented by Shoshani and Eisenberg (1982). The detailed description with special reference to origin, evolution and distribution of each species belongs to Elephantidae was disscused by Maglio (1973).

2 History of study

In India, four species of the Order Proboscidea have been reported as fossils from Pleistocene deposits, but up to now neither *Elephas indicus* Cuvier, 1798 nor *E. maximus* Linnaeus, 1758 in the fossil state has been found in India (Chakravarti, 1965). The four fossil species are *Stegodon insignis-ganesa*, *Elephas* (*Archidiskodon*) *planifrons*, *E. hysudricus* and *E.* (*Palaeoloxodon*) *namadicus*. The first three have been recovered from various Upper Siwalik Subgroup deposits of India (Tatrot, Pinjor, Boulder Conglomerate, and other formations) by Sahni and Khan (1959) and Osborn (1942). *E.* (*P.*) *namadicus* Falconer & Cautley was found in Narmada alluvium deposits of Peninsular India (Sahni and Khan, 1959; Osborn, 1942). Trivedy (1980) noted proboscidean teeth from the Bokabil Formation of Tripura state, India. *Stegodon* sp. also has been reported from Narmada (Badam and Salahuddin, 1982) and Manjra Valley (Joshi et al., 1982) ranging in age from Early to Late Pleistocene. The species *Stegodon insignis* is also reported by Badam (1973) from the Upper Siwaliks around Chandigarh. Age ranges of *E. planifrons* Falconer & Cautley and *E. hysudricus* Falconer & Cautley known from the Tatrot-Pinjor formations (Upper Siwalik Subgroup) are estimated by Opdyke et al. (1979) and Azzaroli and Napoleone (1981). Tripathi and Basu (1983) recovered a jaw of *Elephas* cf. *E. namadicus* containing both left and right upper molars from the Middle Pleistocene alluvial deposits of Narmada Valley (Madhya Pradesh, India). The details of the Pinjor mammalian fauna of the Siwalik Group in relation to the post-Siwalik faunas of Peninsular India and the Indo-Gangetic Plains has been explored by Nanda (2008).

Wadia (1925) first described a tusk of *Stegodon ganesa* which have extraordinary length of over 320 cm recovered from the Jagti village in the Nagrota Formation, Upper Siwalik Subgroup of Jammu near Nagrota village. Lewis (1937) recovered skull of *Elephas* (*Archidiskodon*) *planifrons* from the Tatrot Formation. Following this, Wadia (1951) recovered a tusk and partial skull of *E.* (*A.*) *planifrons* from the Jammu area and another from Pinjor region. Ganjoo (1985) recovered dental remains of *Steogolophodon* sp., *Stegodon insignis-ganesa* and *Elephas* sp. from the Pleistocene deposits of Khanpur Formation (= Pinjor Formation) and Tawi Formation (= Boulder Conglomerate Formation), Upper Siwalik Subgroup of Jammu region. Ganjoo (1992) further reported two species of elephants (*Stegodon insignis-ganesa*, *Archidiskodon planifrons*) from the Upper Siwalik Subgroup of Jammu Province and two other species (*Elephas hysudricus*, *E. namadicus*) from the Pleistocene deposits of Peninsular India. Recently, a complete *Mammuthus* has been recovered from Gallander village, 18 km south of Srinagar city in the Karewas of Kashmir by a four-member team of the department of Geology and Geophysics,

University of Kashmir. Believed to be the largest and earliest *Mammuthus*, it comprises a skull (152.4 cm ×121.9 cm) with complete lower and upper jaw and a broken tusk 83.9 cm long, believed to be 50000 years old (exact dates awaited), and it may have weighed 7 ~ 8 tones (Koul, 2001).

The present study deals with the description of an upper right third molar (RM3) of an *Elephas* recovered from sandy-silty mudstone containing small pebbles about 10 km south of Jammu city near the village Kharian, Jammu Province, Jammu and Kashmir, India (Fig. 1). It is compared with the allied species of *Elephas* and *Mammuthus* to assess its systematic position, distribution and age.

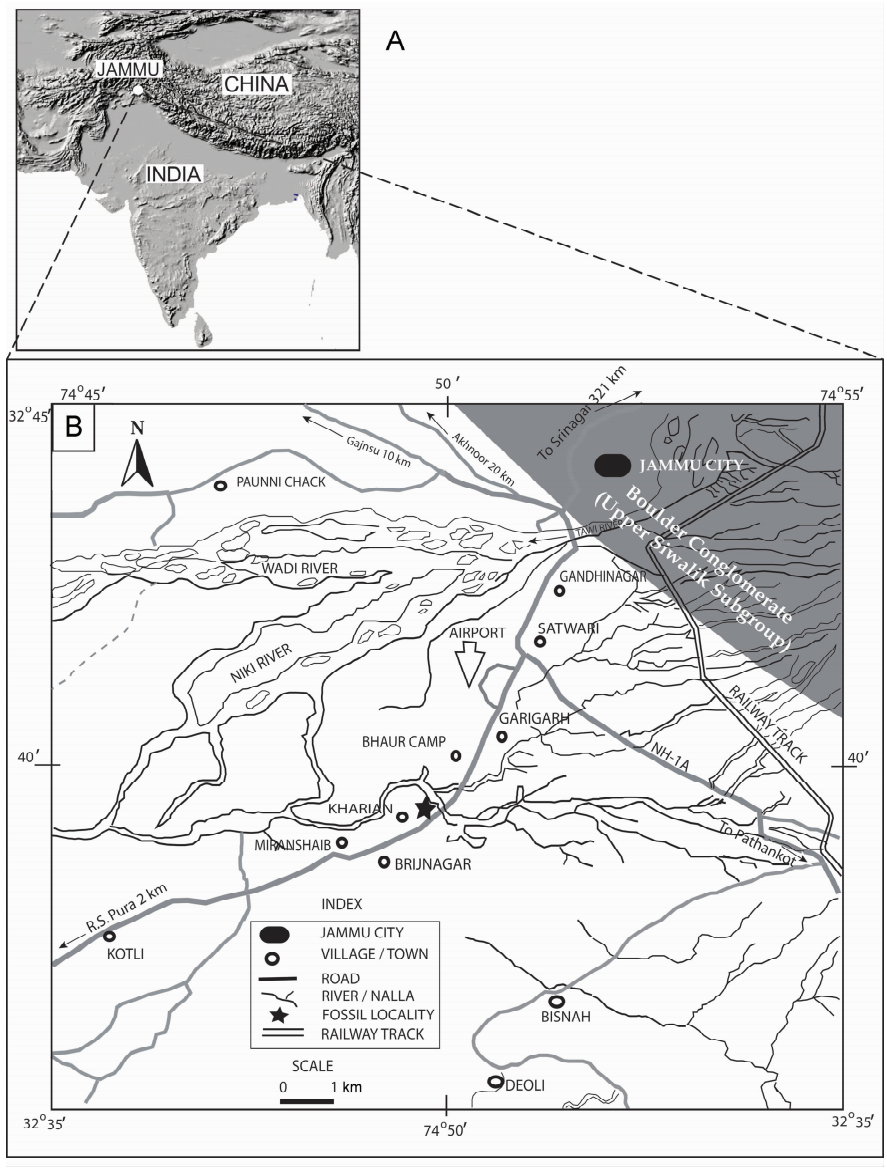

Fig. 1 Map (A) showing area of Jammu Province under study and the locality (B) for the *Elephas* cf. *E. maximus indicus* site overlying the Boulder Conglomerate Formation (Siwalik Group) of Jammu Province

3 Stratigraphy

The term "Siwalik Hills" was coined by Cautley and Falconer (1835) for the Sub-Himalayan ranges occurring between the rivers Ganga and Yamuna that yielded vertebrate fossils around Haridwar. Falconer (1868) was the first to date the Siwalik rocks as Middle Miocene in age. Lydekker (1883) divided the Siwalik deposits into Lower and Upper divisions and recognized the age of the latter as Pliocene. Pilgrim (1910) on the basis of his work (mainly Potwar area) pointed out that the Siwalik succession and its faunas fall into three divisions, i. e. Lower (now known to be Middle Miocene), Middle (Late Miocene) and Upper Siwalik (Pliocene-Early Pleistocene). Pilgrim (1913) gave a classification on the basis of fauna and arranged his faunal zones into nine stages. Pilgrim (1934) further modified his classification with the substitution of Lower Manchar stage by Kamlial stage, combining the lower and upper Chinji stages into Chinji Stage and excluding the Bhandar Beds. Up to the 1970s, this classification was often used in a lithostratigraphic as well as chronostratigraphic sense.

The general stratigraphic succession of Siwalik and post Siwalik formations are

	T4	Holocene
	T3	Late Pleistocene
River Terraces	T2	Late Pleistocene
	T1	Middle Pleistocene
	Boulder Conglomerate	Middle Pleistocene
Upper Siwalik	Pinjor Stage	Late Pliocene-Early Pleistocene
	Tatrot Stage	Early Pliocene
Middle Siwalik	Dhok Pathan Stage	Late Miocene
	Nagri Stage	early Late Miocene
Lower Siwalik	Chinji Stage	Middle Miocene
	Kamilal Stage	Early to Middle Miocene

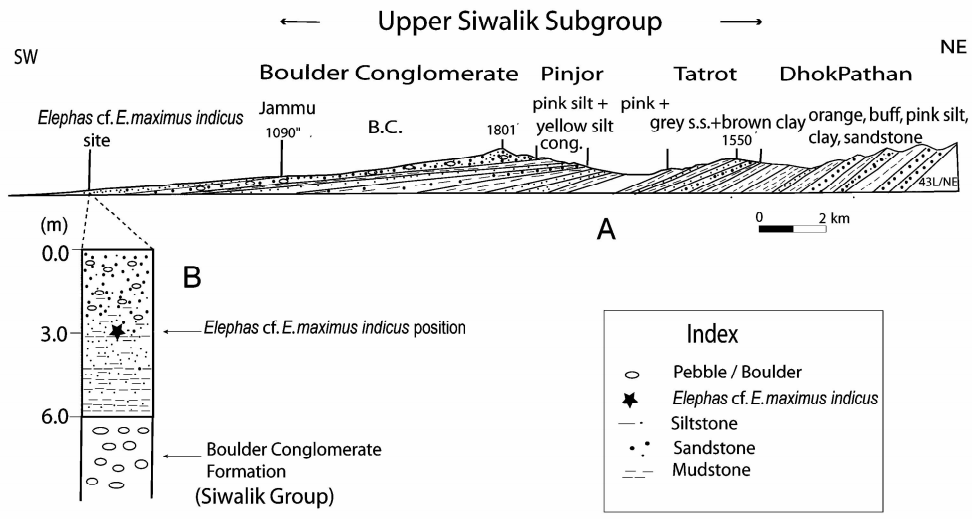

Fig. 2 Profile through front hills near Jammu (modified after De Terra and Teilhard de Chardin, 1936) (A) and GGM/CM/01, *Elephas* cf. *E. maximus indicus* position in stratigraphic column (B)

Geological and paleontological investigations have been carried out on the Siwalik and post-Siwalik deposits of Jammu by various workers from time to time (Colbert,

1935; Lewis, 1937; Wadia, 1957; Opdyke et al., 1982; Johnson et al., 1982, 1985; Ranga Rao et al., 1988; Gupta and Verma, 1988). Gupta and Verma (1988) suggested a new lithostratigraphic classification for the Siwalik succession of Jammu on the basis of lithology and vertebrate paleontology. According to this classification, the Siwalik sequence of Jammu has been divided into the following formations in ascending order: 1) Mansar Formation (Lower Siwalik Subgroup); 2) Dewal Formation and 3) Mohargarh Formation (Middle Siwalik Subgroup); 4) Uttarbhani Formation (Labli and Marikhui Members) and 5) Dughor Formation (Upper Siwalik Subgroup); and River Terraces T1-T3 (Middle Pleistocene-Holocene). The present specimen of *Elephas* under study is recovered from the River Terrace T1 (Middle Pleistocene). The specimen kept in the Government Gandhi Memorial College Museum (GGMCM) formerly known as Prince of Wales College, Jammu, Jammu and Kashmir, India, under Catalogue number GGM/CM/01. The profile through foot hills near Jammu and the locality and stratigraphic position for GGM/CM/01 is given in Fig. 2.

4 Systematic paleontology

Class Mammalia
Order Proboscidea
Superfamily Elephantoidea
Family Elephantidae
***Elephas* Linnaeus, 1758**
Elephas* cf. *E. maximus indicus
(Fig. 3A-G)

Referred material GGM/CM/01, well preserved RM3.

Locality 10 km south of Jammu city near the village Kharian, J&K, India.

Stratigraphic horizon Immediately above the Upper Siwalik Boulder Conglomerate of Jammu Province (Post Siwalik deposits).

Age Middle Pleistocene.

Measurements

Length of molar	270 mm	Lamellar frequency (No. of plates/10 cm)	9
Width of molar	190 mm	Average Enamel Thickness (ET) of worn plates	2.70 mm
Length/Width ratio	1.42	Average Cement Thickness (CT) between plates	3.5 mm
Number of plates	23(14 unworn + 9 worn)	Average Dentine Thickness (DT) of worn plates	4.55 mm
		Crown Length (CL)	240 mm
Average length of plates	160 mm	Crown Width (CW)	85 mm
Average width of plates	59.11 mm	Crown Height (CH)	180 mm
Average thickness of plates	10.77 mm	Hypsodonty Index (HI)	211.76

Description GGM/CM/01 is trapeziform in outline in lateral view. The occlusal enamel loops are moderately thick, consisting of irregular and tight folds. The molar has well preserved plates and multiple roots. Plates are narrow, thin and closely spaced. The worn molar plates have flattened grinding surfaces. Low ridges of dense enamel run across the surface of teeth making them ideal for grinding. The intermediate valleys are filled with cement and valleys between transverse plates are shallow and V-shaped. The anterior nine plates are worn to expose "full plate" characters. The molar ends terminate gradually. The specimen consists of twenty three plates of which fourteen are unworn. Twenty-three plates can be counted on both labial and lingual surfaces. The functional plates slant posteriorly except plates eight and nine. The worn surface of the functional plates is planar, whereas the surface of unworn plates consists of erupted conolets. All unworn plates or ridges taper towards the summit. Wear is slightly greater

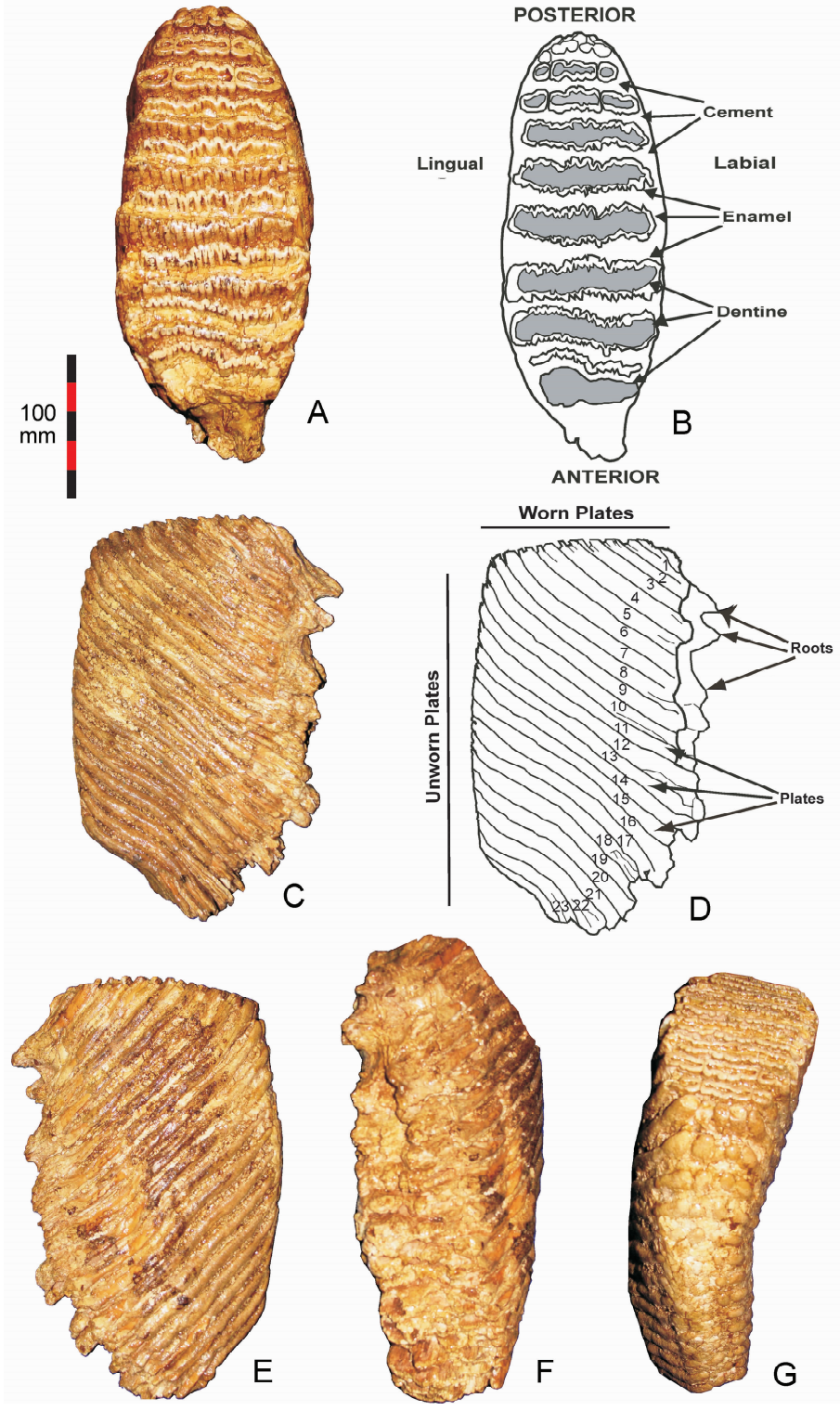

Fig. 3 Upper M3 of *Elephas* cf. *E. maximus indicus*, GGM/CM/01
A-B. in occlusal view, A. photo, B. line drawing; C-D. in labial view, C. photo, D. line drawing; E. photo, in lingual view; F. photo, in root view; G. photo, in occlusal (antero-postero) view

on the labial surface than the lingual surface. The color of enamel is white and of dentine is light brown. The average thickness of enamel of all plates from anterior to posterior is 2.70 mm and that of dentine is 4.55 mm. The average vertical height of enamel above the dentine in all functional plates is 2.78 mm. In occlusal view, the length (width of tooth) of first four functional plates increases from anterior to posterior and after that the size decreases (plates 5-9). In functional plates, the density and complex nature of enamel folds decreases from anterior to posterior. The first plate comprises complex enamel folds, and plate nine shows little folding. The plate descriptions of the molar follow.

Plate-First This plate is broken anteriorly and only the posterior part of the plate (enamel + dentine) is preserved. The enamel does not quite touch the second plate. In occlusal view, the enamel of lingual side is slightly more posterior than enamel of labial side. Expansion of this ridge can be seen towards the posterior. No conolets are erupted in this plate. The valley between plates 1 and 2 is slightly narrower lingually than labially. Transversely, the length of plate (lingual-labial) is 55 mm and width of the plate or ridge (anterior-posterior) is 10 mm. The average vertical height of enamel above the dentine of plate first is about 4 mm (Tables 1-3).

Table 1 Length and width of functional plates(1-9) (mm)

Plate or Ridge number from anterior	Length (labial-lingual) in occlusal view	Width (antero-posterior) in occlusal view	Plate or Ridge number from anterior	Length (labial-lingual) in occlusal view	Width (antero-posterior) in occlusal view
First	55	10	Sixth	60	11
Second	62	12	Seventh	55	9
Third	70	15	Eighth	50	7
Fourth	72	15	Ninth	43	5
Fifth	65	13			

Plate-Second All the crown features are well preserved in this plate, despite slight lingual and labial breakage. The plate shows expansion at the middle. The posterior enamel of the plate shows dense complex and large folds unlike the anterior enamel of the plate. The lingual side of the plate is slightly more posterior than labial side which is relatively anterior. The valley between plates 2-3 is very narrow lingually and wider towards the labial side. Vertically, the enamel of plate slants posteriorly toward the roots. No conolet is present. Transversely, the length of the ridge is 62 mm and width (anterior-posterior) of the ridge is 12 mm (Table 1). The vertical average height of anterior and posterior enamel above the dentine is 2 and 4 mm, respectively (Table 3).

Table 2 Dentine length and width of functional plates(1-9) (mm)

Dentine of plates or ridges from anterior	Length of dentine (labial-lingual) in occlusal view	Width of dentine (antero-posterior) in occlusal view	Dentine of plates or ridges from anterior	Length of dentine (labial-lingual) in occlusal view	Width of dentine (antero-posterior) in occlusal view
First	52	5	Sixth	57	5
Second	59	5	Seventh	52.5	4
Third	67	5	Eighth	47.5	3
Fourth	69	7	Ninth	41	2
Fifth	63	5			

Plate-Third Transversely, the plate is straight among the functional plates and forms a full enamel loop. The plate is slightly broken on both lingual and labial sides. The central part of the plate, which shows complex folding of its enamel, extends more posteriorly than at the labial

and lingual ends. The pinch and swell nature of the dentine can be seen in the plate. No conolets are preserved in the lamella. The valley between plates 3-4 is very narrow at the center and widens both lingually and labially. The enamel and dentine of the plate slant posteriorly on the anterior side of the lamella, but the posterior side is almost vertical. This characteristic is true for all functional plates present in the present tooth. Very complex and dense folds can be seen in the enamel of this plate. The transverse length of the plate is 70 mm, width of ridge from anterior to posterior is 15 mm, and width of dentine is 5 mm (Tables 1, 2). The average vertical height of anterior enamel above dentine is 3 mm and that of posterior enamel is 5 mm (Table 3).

Table 3 Average height of enamel above dentine of functional plates (occlusal view) (mm)

Plate or Ridge number from anterior	Enamel plate position in occlusal view	Average height of enamel above dentine, occlusal view	Plate or Ridge number from anterior	Enamel plate position in occlusal view	Average height of enamel above dentine, occlusal view
First	Anterior	broken	Sixth	Anterior	2
	Posterior	4		Posterior	3.5
Second	Anterior	2	Seventh	Anterior	2
	Posterior	4		Posterior	2.5
Third	Anterior	3	Eighth	Anterior	1
	Posterior	5		Posterior	1
Fourth	Anterior	2	Ninth	Anterior	nil
	Posterior	4		Posterior	nil
Fifth	Anterior	2			
	Posterior	4			

Plate-Fourth In occlusal view the fourth plate is the widest of all plates and is well preserved with clear enamel and dentine features. The dentine and enamel of the plate are broken slightly lingually and labially. In the central part of this ridge, enamel folds and dentine are slightly less complex and dense than plate third. The enamel of the plate inclines slightly posteriorly. The valley width between plates 4-5 is constant transversely, but labially near the center the valley widens. The border of this plate does not touch plate 3 or 5, but expansion of the plate can be seen at the center, and conolets are evident in the ridge. The folds occurring in this plate are less complex and dense than the third plate. Transversely, length of fourth ridge is 72 mm and width is 15 mm, dentine width in the ridge is 7 mm, and vertical height of enamel above the dentine of the ridge is 2 mm anteriorly, 4 mm posteriorly (Tables 1-3).

Plate-Fifth The fifth plate resembles the fourth, and shows well preserved dentine and enamel features, but is somewhat smaller. This plate is also slightly broken labially and lingually. The central portion of the ridge is wider than the labial and lingual portions and swells slightly posteriorly, making the valley between plate 5 and 6 narrow at the center. The enamel folds are less complex and dense than in the fourth, but the thickness of enamel is greater than in anterior lamellae. No conolet is preserved in this plate. The surface of the ridge is slightly convex as in other plates, and the plate slants posteriorly. The length of the ridge from lingual to labial is 65 mm and width from anterior to posterior is 13 mm (Table 1). The average width of dentine from anterior to posterior is 5 mm (Table 2). The average vertical heights of anterior and posterior enamel above the dentine are 2 and 4 mm (Table 3).

Plate-Sixth Transversely, this plate is nearly straight, smaller in size than the fifth and larger than the seventh. The lamellae show decrease of size of dentine and enamel thickness. The dentine is wider at center than lingually and labially. The enamel folds are less dense than in anterior plates, but the dentine shows pinch and swell structure. The sloping angle of ridge enamels is slightly less than in anterior plates. No conolets are preserved in the ridge. The plate

length is 60 mm and width is 11 mm (dentine is 5 mm), and the average vertical height of anterior and posterior enamel of ridge are 2 and 3.5 mm (Tables 1-3).

Plate-Seventh The seventh plate consists of three well preserved loops. Of these, the second enamel loop is the biggest one, followed by labial, then lingual loops. The central loop is more expanded antero-posteriorly (9 mm wide) and its labial-lingual length is 16 mm. The similar length and width of each of other two figures are 15 and 7 mm. A few folds can be seen in the central figure whereas folds are absent in other two loops. The shape of central enamel figure is nearly elliptical. Transversely, the ends of the central figure touch the lingual and labial enamel figures. The valley between plates 7 and 8 is narrow at the center and wider towards lingual and labial sides. The plate slants slightly posteriorly. Transversely the ridge length is 55 mm and width is 9 mm (Table 1), average width of the dentine in this plate is 4 mm (Table 2), and the average vertical height of anterior and posterior enamel above the dentine are 2 and 2.5 mm, respectively (Table 3).

Plate-Eighth Plate eight also consists of three enamel figures, but is smaller than the seventh. Of the three enamel figures, the central enamel figure is biggest, followed by labial and lingual loops. The labial enamel figure is slightly broken. The central figure is expanded both transversely and antero-posteriorly, and shows well preserved pinch and swell features of the dentine. The central loop touches the labial and lingual enamel figures. All the enamel figures are elliptical. The length of the lamella is 50 mm and width is 7 mm (Table 1). The average vertical height of anterior and posterior enamel above dentine is 1 mm (Table 3) and the width of dentine is 3 mm (Table 2).

Plate-Ninth This plate consists of five well preserved conolets, all slightly worn. The first and fourth conolets from the labial side are the biggest and the other three are of approximately the same smaller size. The shape of each conolet is nearly circular and they are arranged transversely. Labially, the worn plates are slightly convex. No conolet touches another. In occlusal view, the length of the ridge is 43 mm and width is 5 mm (Table 1). The width of dentine from anterior to posterior is 2 mm (Table 2).

The thickness of enamel on the leading and trailing margins of worn plates is shown in Table 4. The posterior fourteen plates or lamellae are unworn and embedded in thick cement. Their presence can be detected in lateral view. Plates 10-23 in lateral view are convex posteriorly, and show presence of five conolets. The roots are well preserved and can be seen from lingual and labial surfaces. There is no doubt that the molar is the last (3^{rd}) as it shows very clear tapering posteriorly. The enamel is smooth and shows complex to normal folding from anterior to posterior.

Table 4 Average width (thickness) of enamel of functional plates from anterior to posterior (occlusal view)

(mm)

Plate number	Plate enamel	Average thickness	Plate number	Plate enamel	Average thickness
First	Anterior	broken	Sixth	Anterior	3
	Posterior	3		Posterior	3
Second	Anterior	3	Seventh	Anterior	2.5
	Posterior	3		Posterior	2.5
Third	Anterior	3	Eighth	Anterior	2.5
	Posterior	3		Posterior	2.5
Fourth	Anterior	3	Ninth	Anterior	2
	Posterior	3		Posterior	2
Fifth	Anterior	2			
	Posterior	3			

5 Comparative study of specimen GGM/CM/01 with allied species of *Elephas* and *Mammuthus*

By using the molar morphological parameters such as plate number, length and width of molar, width and height of crown, lamellar frequency, enamel thickness and hypsodonty index, the present specimen GGM/CM/01 is compared with closely related elephantines (*Archidiskodon planifrons*, *Elephas hysudricus*, *E. namadicus*, *E. hysudrindicus*, *E. naumani* and *E. maximus*, Table 5). *Archidiskodon planifrons* is differentiated from the GGM/CM/01 by the median expansion of the lophs and complete absence of crenulation or plication, which are the characteristic features of the species (Osborn, 1942). On the other hand, *Elephas hysudricus* is characterized by having strong plication of lophs and the lack of median expansion. Similarly the absence of any median expansion and parallel lophs is very characteristic of *Elephas namadicus* (Ganjoo, 1992). The number of plates in GGM/CM/01 is 23, compared to *Elephas planifrons* (10 ~ 12), *E. hysudricus* (12 ~ 15), *E. hysudrindicus* (18 ~ 21), *E. maximus* (22 ~ 27), *E. namadicus* (12 ~ 16) and *E. naumani* (17 ~ 19). The length of GGM/CM/01 is 270 mm, which falls in or near the observed ranges of length of *E. planifrons* (201 ~ 292 mm), *E. hysudricus* (235 ~ 302 mm), *E. hysudrindicus* (293.2 ~ 316.6 mm), *E. maximus* (244 ~ 282 mm), *E. namadicus* (223 ~ 317 mm) and *E. naumani* (211 ~ 278 mm). The width and height of crown of GGM/CM/01 is 85 and 180 mm, compared to *E. planifrons* (86 ~ 111, 76 ~ 129 mm), *E. hysudricus* (93 ~ 107, 108 ~ 137 mm), *E. hysudrindicus* (72.3 ~ 82.5, 128.4 ~ 149.3 mm), *E. maximus* (80 ~ 98, 187 ~ 214 mm), *E. namadicus* (61 ~ 101, 137 ~ 218 mm) and *E. naumani* (81 ~ 95, 195 ~ 251 mm). The lamellar frequency, enamel thickness and hypsodonty index of the GGM/CM/01 specimen is 9, 2.7 and 211.76. However, the allied species differ somewhat, except for *E. maximus*: *E. planifrons* (2.6 ~ 5.5, 2.8 ~ 4.8, 80 ~ 110), *E. hysudricus* (3.9 ~ 6.5, 2.5 ~ 4.8, 112.5 ~ 147.2), *E. hysudrindicus* (6.5, 2.6 ~ 2.7, 177.5 ~ 182.3), *E. maximus* (5 ~ 9, 2.5 ~ 3.0, 150 ~ 250), *E. namadicus* (4.5 ~ 7.7, 1.8 ~ 3.0, 135.6 ~ 298.6) and *E. naumani* (6 ~ 7, 2.0 ~ 3.2, 230 ~ 320). Based on the above comparative data and morphological parameters GGM/CM/01 most closely matches *E. maximus*.

By using the same molar morphological features, GGM/CM/01 can also be compared with allied species of *Mammuthus* (Table 6). GGM/CM/01 is differentiated from *Mammuthus subplanifrons*, *M. africanavus*, *M. meridionalis*, and *M. armeniacus*, by plate number, length of molar, width and height of crown, lamellar frequency, enamel thickness and hypsodonty index. Only one species of *Mammuthus*, *M. primigenius* appears close to the GGM/CM/01.

The plate number of *E. maximus*, *M. primigenius* and GGM/CM/01 are 22 ~ 27, 20 ~ 27, and 23 and the lamellar frequency is 5 ~ 9, 6.5 ~ 11.1 and 9. Similarly the molar length of *E. maximus*, *M. primigenius* and GGM/CM/01 is 244 ~ 282, 226 ~ 285, 270 mm, width of crown is 80 ~ 98, 68 ~ 113, 85 mm and height of crown is 187 ~ 214, 135 ~ 188.5, 180 mm. The hypsodonty index of the *E. maximus*, *M. primigenius* and GGM/CM/01 is 150 ~ 250, 164.6 ~ 211 and 211.76.

The comparative study suggests that GGM/CM/01 resembles both *E. maximus* (living Indian elephant) and *M. primigenius* (extinct woolly mammoth). From the occlusal view, the enamel of worn plates of GGM/CM/01 shows irregular and tight loph or fold structures. This is the characteristic feature of *E. maximus*. In contrast, *M. primigenius* has extremely thin and parallel laminae. The outline marginal shape of GGM/CM/01 is similar to *M. primigenius*. Some crown parameters are shared except enamel thickness, hypsodonty index, extremely thin and parallel lamellae, and lamellae without irregular and tight folds of enamels. The range of variation of enamel thickness and the geological interval in which GGM/CM/01 falls is plotted on Aguirre's chart (Aguirre, 1969, our Fig. 4).

Table 5 Comparative measurements of GGM/CM/01 with allied species of *Elephas* (upper third molar)

	Character	*E. planifrons*	*E. hysudricus*	*E. hysudrindicus*	*E. naumani*	*E. namadicus*	*E. maximus*	Present specimen
1	Number of plates (N)	10 ~ 12	12 ~ 15	18 ~ 21	17 ~ 19	12 ~ 16	22 ~ 27	23
	Mean	11	13.5	19.5	18	14.3	24.5	
2	Length of molar (L) (mm)	201 ~ 292	235 ~ 302	293.2 ~ 316.6	211 ~ 278	223 ~ 317	244 ~ 282	270
	Mean	238.2	267.7	304.9	244.5	270	271.9	
3	Width of crown (W) (mm)	86 ~ 111	93 ~ 107	72.3 ~ 82.5	81 ~ 95	61 ~ 101	80 ~ 98	85
	Mean	98.7	97.2	77.4	88	84	89	
4	Height of crown (H) (mm)	76 ~ 129	108 ~ 137	128.4 ~ 149.3	195 ~ 251	137 ~ 218	187 ~ 214	180
	Mean	94.2	125.4	138.8	223	175.5	200.5	
5	Lamellar Frequency (LF)	2.6 ~ 5.5	3.9 ~ 6.5	6.5	6 ~ 7	4.5 ~ 7.7	5.0 ~ 9.0	9
	Mean	4.2	5.4		6.5	5.7	7	
6	Enamel thickness (ET) (mm)	2.8 ~ 4.8	2.5 ~ 4.8	2.6 ~ 2.7	2.0 ~ 3.2	1.8 ~ 3.0	2.5 ~ 3.0	2.7
	Mean	3.9	3.2	2.6	2.6	2.4	2.75	
7	Hypsodonty Index (HI)	80 ~ 110	112.5 ~ 147.2	177.5 ~ 182.3	230 ~ 320	135.6 ~ 298.6	150 ~ 250	211.76
	Mean	97.6	131.2	179. 9	275	212.4	200	

Note: Figures are observed range and mean.

Table 6 Comparative measurements (observed range and mean) of GGM/CM/01 with species of *Mammuthus* (upper third molar)

	Character	*M. subplanifrons*	*M. africanavus*	*M. meridionalis*	*M. armeniacus*	*M. primigenius*	GGM/CM/01
1	No. Plates	7 ~ 8	9	11 ~ 14	14 ~ 21	20 ~ 27	23
	Mean	7.5		12.8	18.6	23.2	
2	Length of Molar (L) (mm)	202.8 ~ 229.2	267.8	228.8 ~ 317.1	213 ~ 358	226 ~ 285	270
	Mean	215.3		273	293	263	
3	Width of Crown (W) (mm)	81 ~ 122	81.8 ~ 108	85.6 ~ 126.4	57 ~ 107.5	68 ~ 113	85
	Mean	96.9	95.9	104.8	85.2	92.5	
4	Height of Crown (H) (mm)	49 ~ 85	74.9 ~ 110.9	100.2 ~ 141.8	118 ~ 218	135 ~ 188.5	180
	Mean	67.8	94.9	122.7	162.5	168.1	
5	Lamellar Frequency (LF)	2.6 ~ 4.1	3 ~ 4.4	3.7 ~ 6.1	5.0 ~ 8.2	6.5 ~ 11.1	9
	Mean	3.3	3.9	4.9	6.5	9.0	
6	Enamel Thickness (ET) (mm)	3.4 ~ 5	3.2 ~ 4.6	2.6 ~ 4.1	1.5 ~ 3.0	1.3 ~ 2.0	2.7
	Mean	4	3.6	3.3	2.2	1.6	
7	Hypsodonty Index (HI)	56.3 ~ 91.0	72.2 ~ 119	93.8 ~ 152	145.3 ~ 304	164.6 ~ 211	211.76
	Mean	74.5	98.3	125.6	199.7	184.4	

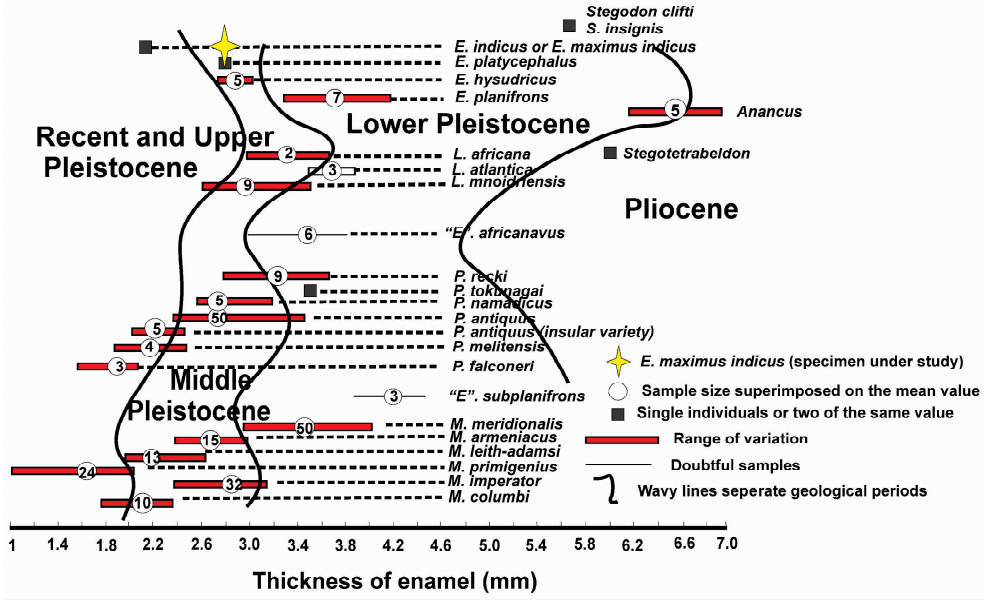

Fig. 4 *Elephas* cf. *E. maximus indicus* (GGM/CM/01, large star) plotted on chart of Aguirre (1969) Species of elephants showing range of variation of enamel thickness and geological age

6 Distribution of extinct and extant species of *Elephas* in Indian Subcontinent

The distribution of extinct and extant species of *Elephas* in the Indian subcontinent is depicted in Fig. 5. The type locality of *Elephas namadicus* is in the Narmada Valley, India, and it is reported from Godwary Valley. This species has also been recovered from the Middle to Late Pliocene deposits of Europe, the Middle East, and elsewhere in Asia. The type locality of *Elephas planifrons* is Pinjor, and it was also recovered from the Tatrot Fm., Upper Siwalik Subgroup of India. This species is also recovered from the Late Pliocene-Early Pleistocene elsewhere in Asia and the Middle East. *Elephas hysudricus* occurs in the Late Pliocene to early Pleistocene of Asia, the type locality being the Pinjor horizon, Upper Siwaliks of India. The

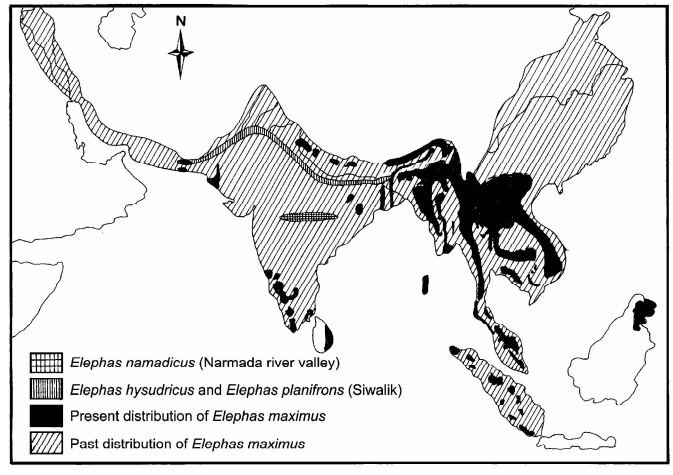

Fig. 5 Map showing distribution of extinct and extant species of *Elephas* in Indian subcontinent

species has also been recovered from the Karewas of Kashmir, India, and Upper Irrawaddy beds of Burma. *Elephas platycephalus* was recovered from Early Pleistocene-Middle Pleistocene of Amilee Creek, near Siswan, Simla, India, and it is the only known specimen. The present and past distribution of *Elephas maximus* is also plotted on Fig. 5. This species is known from many Recent to Subrecent localities from India. During the Early Pliocene to Late Pliocene *E. maximus* was distributed in Africa and it emigrated by the Late Pliocene-Early Pleistocene to Eurasia (Shoshani and Eisenberg, 1982).

7 Conclusion

Based on molar morphology, it is concluded that GGM/CM/01 shows closer affinity to *E. maximus* (living Indian Elephant) than to *M. primigenius* (extinct woolly mammoth). The recovery of this molar (*Elephas* cf. *E. maximus indicus*) from the sandy-silty mudstone immediately overlying the Boulder Conglomerate Formation of the Siwaliks (Upper Subgroup) as plotted on Fig. 4 derived from Aguirre (1969) indicates that the age of the specimen is likely Middle Pleistocene. *Elephas maximus*, distributed in Africa during the Early Pliocene to Late Pliocene, migrated to Eurasia and Indian Subcontinent, probably at the end of the Pliocene.

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