A Late Pliocene Baby *Stegodon* cf. *Stegodon insignis* (Proboscidea) from Upper Siwalik of Samba District, Jammu and Kashmir, India

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ABSTRACT

One complete molar of a baby *Stegodon* is reported from the road-cutting section of the mudstone horizon of Nagrota Formation exposed about 2km south of Labli village. The molar yielding horizon underlies geochronologically dated (2.48 ma) volcanic ash bed which is the extension of Barakheter-Uttarbaini ash bed in the Uttarbaini Formation (Nagrota Formation/ Pinjor Formation), Upper Siwalik Subgroup, Samba district, Jammu & Kashmir, India. Based on the molar morphological parameters, the specimens have been identified and tentatively referred to *Stegodon* cf. *Stegodon insignis* (a baby *Stegodon*). A brief about the age, migration and distribution of *Stegodon* is also discussed in the present paper.

Keywords: Late Pliocene, *Stegodon* cf. *Stegodon insignis*, Upper Siwalik, Samba District, Jammu and Kashmir, India

INTRODUCTION

The extinct subfamily Stegodontinae of Proboscidea comprises of two genera namely *Steglophodon* (blunter ridges with rounded conules) and *Stegodon* (hoofed roofed with compressed teetiform ridges). Fossils of both the *Steglophodon* and *Stegodon* have been recovered in India. *Stegodon* has an intermediate position between mastodonts and typical elephants (Falconer, 1857) and is represented by the following species in Indian subcontinent: *Stegodon insignis*, *S. ganesa*, *S. bombifrons*, *S. elephantoides* (= *S. cliftii*), *S. pinjorensis*, *S. katliensis*, *S. zdanskyi*, *S. officinalis*, *S. bondolensis*, *S. aurorae*, *S. airawana*, *S. trigonocephalus*, *S. orientlis*, *S. sinensis*, *S. orientlis shodoensis*, *S. trigonocephalus praeursor*. The detailed work on the geological, palaeontological, ecological implications, taxonomy, diet, migration, distribution and phylogentic studies on *Stegodon* in Indian subcontinent has been carried out by number of workers (Sahni and Khan, 1961; Hooijar, 1955, 1964; Chakravarti, 1965; Aguirre, 1969; Moglio, 1973; Badam, 1973; Badam and Sharma, 1973; Tobien, 1977; Nanda, 1980; Badam and Salahuddin, 1982; Badam and Kumar, 1982; Joshi *et al.*, 1982; Ann, 1985; Nanda, 1988; Arif and Hussain, 1992; Lamba, 1993; Nanda and Corvinus, 2000; Rai, 2004; Samiullah *et al.*, 2014; Nanda, 2015).

The Siwalik of Jammu lies in an intermediate position between the Potwar Plateau in the west and the Himachal Pradesh in the east. A number of workers have recorded and

studied the Proboscidean fauna of Jammu Siwaliks (Wadia, 1925; Ganjoo, 1985; Ganjoo, 1992; Verma *et al.* 2002; Kundal and Kundal, 2011; Kundal *et al.*, 2017). Wadia (1925) recovered a tusk of *Stegodon ganesa* having length of about 11 feet 5 inch from Nagrota Formation, Upper Siwalik Subgroup exposed near the village Jagti in Jammu district. Ganjoo (1985) recovered dental remains of *Stegolophodon* sp., *Stegodon insignis-ganesa* and *Elephas* sp. from the Pleistocene deposits near village Kirli, Rajpul and Dewan of Khanpur Formation (Pinjor Formation) and Tawi Formation (Boulder Formation) of Upper Siwalik Subgroup of Jammu region.

Further, Ganjoo (1992) recovered molars of *Stegolophodon* sp. and *Stegodon* sp. from the section very near to Jagti in the Pinjor Formation of Upper Siwalik of Jammu and gave their ecological implications. Recently Kundal and Kundal (2011) recovered a molar of *Elephas* cf. *Elephas maximus indicus* from the post-Siwalik deposits of Jammu. A good number of specimens (*Stegolophodon* species, *Stegodon bombifrons*, *Stegodon* sp., *Stegodon insignis*, *Stegodon ganesa*, *Elephas planifrons*, *Elephas hysudricus*) collected from Nagrota Formation (= Pinjor Formation) of Jammu Siwalik by Geological Survey of India Scientists and have been recorded by Verma *et al.* (2002). A good number of proboscidean specimens has been described in the WIHG monograph series, number 2 (Nanda, 2015). Very recently Kundal *et al.* (2017) recovered a third molar of *Elephas* cf. *Elephas planifrons* from the mudstone horizon immediately underlying the geochronologically dated volcanic ash bed exposed at Nangal village which is the extension of Barakhetar ash beds in the Nagrota Formation (= Pinjor Formation) of Upper Siwalik Subgroup of the Jammu province, J&K, India and extended its range zone. A good number of species of microfossils (ostracodes, gastropods) and microvertebrates have also recovered from the same horizon (Prasad *et al.*, 2005; Bhat *et al.*, 2008; Bhandari and Kundal, 2008; Kundal and Prasad, 2011; Kundal, 2013; Kundal, 2015).

In the present study, a complete molar of *Stegodon* cf. *Stegodon insignis* (baby) of Late Pliocene age recovered from the mudstone horizon underlying the geochronological dated (2.48 my) bentonitized tuff band exposed at Anandpur village about 2 km south of Labli village and 1.5 km east of Uttarbaini ash bed, Upper Siwalik of Samba District has been described (Fig.1). A brief about age, migration and distribution of the *Stegodon* is also discussed in the present paper.

Siwalik rocks occupy the southern margin of Himalaya separated from lesser Himalaya by Main Boundary Thrust (MBT) in the north whereas Himalayan Frontal Fault (HFF) in the south separates it from Indo-Gangetic plains. The Siwalik succession is thicker in northwestern part (Pakistan) and thinner towards northeast (India and Nepal). The average thickness is about 5-6 km. All the type sections of the Siwaliks are in the Pakistan except one namely Pinjor in India. Stratigraphically, the Siwalik Group is classified into three Subgroups and seven Formations viz. Lower Siwalik Subgroup (Kamlial and Chinji formations), Middle Siwalik Subgroup (Nagri and Dhokpathan formations) and Upper Siwalik Subgroup (Tatrot, Pinjore and Boulder Conglomerate formations).

The classification of Jammu Siwalik has been given by number of geoscientists (Ranga Rao *et al.*, 1988; Gupta and Verma, 1988; Agarwal *et al.*, 1993 and Gupta, 2000) from time to time and correlated it with standard classification of the Siwalik given by Pilgrim (1934). The comparative lithological classification of Siwalik Group of rocks in Jammu is given in Table-1.

Fig. 1: A. Map showings disposition of Siwaliks in Himalayan foreland basin, B. Geological map of the study area showing *Stegodon* location, C. Position of *Stegodon cf. Stegodon insignis* in the lithocolumn.

Table-1: Lithostratigraphic classifications of the Siwalik sequence of Jammu region

		Ranga Rao <i>et al.</i> , 1988	Agarwal <i>et al.</i> , 1993	Gupta and verma, 1988; Gupta, 2000	Classical subdivisions	Age
SIWALIK GROUP	Upper Siwalik subgroup	Boulder Conglomerate		Dughor Formation	Boulder Conglomerate	Lower Pleistocene
		Nagrota Formation	Nagrota Member A	Uttarbaini Formation	Marikhui Member	Lower Pleistocene
			Nagrota Member B			
			Nagrota Member C			
		Parmandal Sandstone		Labli Member	Tatrot Formation	Upper Pliocene
	Middle Siwalik subgroup			Mohargarh Formation (= Parmandal Sandstone of Ranga Rao <i>et al.</i> 1988)	Dhok Pathan Formation	Middle Pliocene
				Dewal Formation	Nagri Formation	Lower Pliocene
	Lower Siwalik Subgroup			Mansar Formation	Ramnagar Member	Upper Miocene
					Dodenal Member	Middle Miocene

SYSTEMATIC PALAEONTOLOGY

Class Mammalia Linnaeus
Order Proboscidea Illiger, 1811
Family Elephantidae Gray 1821
Subfamily Stegodontinae, Osborn, 1918
Genus *Stegodon* Falconer & Cautley, 1847
Stegodon cf. Stegodon insignis Falconer and Cautley, 1846
(Fig. 2 A-F)

Referred Material: JU/DG/VPL/9002, Upper right molar, RM² complete molar.

Locality: near Anandpur village, district Samba, (Jammu and Kashmir). The section is about 2 km south of Labli village and 1.5 km east of Uttarbaini.

Horizon: Nagrota Formation (Ranga Rao *et al.*, 1988)/ Uttarbaini Formation (Gupta and Verma, 1988) / Pinjore Formation (Pilgrim, 1934); underlying ash beds

Age: Late Pliocene

Measurements: length of molar=110 mm, width of molar=60 mm, length/width ratio of molar=1.83, number of ridges=9, average length of ridges (occlusal, lingual-labial)=50mm, average width of ridges (occlusal, anterior - posterior)=13.55mm, lamellar frequency (LF)=8mm, average enamel thickness (ET) of worn ridges= 2mm, average cement thickness (CT) between ridges=8.83mm, average dentine thickness (DT) of worn ridges=2.2 mm, crown length (CL)=110mm, Crown width (CW)=50mm, maximum crown height=55mm, hypsodonty Index (H/Wx100)=110

Description: well preserved specimen consists of nine ridges. Each ridge consists of at least eight conelets. The conelets of anterior three ridges are worn out to form worn ridges. The molar curvature is straight and has parallel sides. The width of molar from the base of crown is greatest. The inclination of ridges to occlusal surface is weak. The valleys between the ridges are completely filled with thick cement and shows “V” shaped pattern. The roots of the molar are not well preserved. Many apical digitations in form of conelets were preserved. The complete enamel loop only preserved in worn plates. The specimen has neither anterior nor posterior columns, except in plate second which shows little bit strong posterior column. The molar height is more in the middle than at anterior and posterior ends. The conelets of each ridge is covered with thick cement and thickness of cement increases from anterior to posterior.

Fig. 2: *Stegodon* Molar: A. Occlusal View (Anterior-Posterior), B. Line drawing Occlusal view (Anterior-Posterior), C. Occlusal-lateral view, D. Labial-lateral view E. Lingual lateral view and F. Roots view.

The ridge wise description of JU/DG/VPL/9002 specimen from anterior to posterior is given below:

Ridge first: Well worn plate with little bit broken anterior enamel. The length (lingual-labial) of the plate is 40 mm in occlusal view and width (anterior-posterior) is 4 mm the crown height above the roots is 22 mm and enamel thickness is 1mm. The thickness of cement between plates first and second is 3 mm. This plate is distinct from other plates has it extends towards labial than other plates. This plate is the anterior most plate of the molar.

Ridge second: The plate has well exposed enamel, dentine and cement with small folds at the centre of plate in occlusal view. This plate is well preserved and worn out. The length of plate is 42 mm and width is 13 mm. The crown height is 30 mm above the roots. The enamel thickness of plate is 2 mm and dentine thickness is 3 mm. The cement thickness between plates second and third is 10mm.

Ridge third: Half worn plate consists of nine conelets. The three conelets from lingual side are broken while remaining conelets are exposed with enamel, dentine and cement. The plate is well preserved and shows folding at the centre towards lingual side. In occlusal view, the length (lingual-labial) of plate is 48 mm and width (anterior-posterior) is 14 mm. The enamel thickness of this plate is 2 mm and average dentine thickness is 2.5 mm. The plate has 35 mm crown height above the roots.

Ridge fourth: This plate consists of seven conelets. The conelets at the centre of plate are worn out but towards lingual and labial they are unworn. The dentine, enamel and cement thickness of worn conelets has been measured. The length (labial-lingual) and width (anterior-posterior) of worn conelets ridge is 50 mm and 15 mm respectively. The crown height above the roots is 48 mm and the enamel thickness is 2 mm. the average dentine thickness of worn conelets is 2 mm and the cement thickness between plates fourth and fifth is 11 mm.

Ridge fifth: Completely unworn plate and consists of well preserved eight conelets. The diameter of unworn conelets varies in size from 1.5 mm at the lingual and labial to 3 mm at the center of the plate. The length and width of the plate is 52 mm and 15 mm respectively. The crown height above the roots is 52 mm. The enamel thickness and dentine thickness could not be measured as the conelets are not worn out. The cement thickness between plates fifth and sixth is 11mm.

Ridge sixth: Well preserved unworn plate with eight conelets. The diameter of conelets varies from 1mm to 4 mm. The length and width of plate is 55 mm and 12 mm respectively. The plate shows 56 mm crown height above the roots. The dentine and enamel thickness could not be measured as the conelets are not worn out. The cement thickness between plates sixth and seventh is 9 mm.

Ridge seventh: Well preserved plate with eight conelets. Diameter of conelets varies from 2 mm to 5 mm. the length and width of plate is 57 mm and 13 mm respectively. The crown height of this plate is 57 mm and the thickness of cement between plates seventh and eighth is 9 mm.

Ridge eighth: This plate consists of nine conelets. All the conelets are broken except two at the centre of plate. The diameter of conelets not properly measured but estimated maximum diameter is 4 mm. The length and width of plate is 52 mm and 16 mm respectively. The maximum crown height of the plate above the roots is 42 mm and thickness of cement between plates eighth and ninth is 10 mm.

Ridge ninth: Plate consists of six broken conelets. The length and width of plate is 40 mm and 6 mm (+ 6mm half broken posteriorly) respectively. The crown height above the roots is 32 mm. Due to the broken occlusal surface of the conelets the dentine and enamel thickness could not be measured.

COMPARATIVE STUDY WITH THE ALLIED SPECIES OF INDIAN SUBCONTINENT

By using the dental morphological parameters (plate/ridge numbers, length, width and height of molar, enamel thickness, crown height, crown width, lamellar frequency, hypsodonty index, etc.) the specimen under study has been compared with the allied species of *Stegodon* (*Stegodon bombifrons*, *Stegodon elephantoides* (*cliftii*), *Stegodon pinjorensis*, *Stegodon insignis birmanicus*, *Stegodon insignis*, *Stegodon ganesa*) known from India, Pakistan and Burma from time to time by the palaeontologists. The *Stegodon bombifrons* differentiated from present specimen having nine and half plates or ridges and each plate consists of eleven or more than eleven conelets. *Stegodon elephantoides* (=cliftii) differentiated from specimen understudy having eight and half plate and each plate consists of ten or more conelets and each plate is not coated with thick cement. *Stegodon pinjorensis* has eleven and half to thirteen plate or ridges, but the specimen under discussion have nine plate or ridges. *Stegodon insignis birmanicus* is differentiated from the specimen understudy having twelve to fifteen plate ridges and the plate ridges covered with thin cementing material. The specimen under discussion is also compared with the *Stegodon insignis* and *Stegodon ganesa* which may represent a female and a male respectively of the same species. M³ of *Stegodon insignis* has ten plates or ridges but the *Stegodon ganesa* has eleven plates or ridges and each ridge consists of eleven conelets. The present specimen is compared with *Stegodon insignis-ganesa* having nine plates or ridges and each ridge consists of eight conelets except last posterior plate of molar which have preserved six conelets and resembles *Stegodon insignis-ganesa*. Each plate of the present described specimen is coated with thick cement and the cement thickness increases from anterior to posterior which resembles with *Stegodon insignis*. On the other hand, the quantity of cement coating is less in case of *Stegodon ganesa*. As the specimen was a baby *Stegodon* so it has thin enamel figure, high lameller frequency and thick cement. Had it been an adult the dimension of the tooth would have been 330 mm and the corresponding enamel thickness of 6 mm and LF is 4. Given this analogy of the specimen with an adult and its comparison with the specimen number 19801, right upper second molar at American Museum collected by Barnum Brown from Pinjor horizon (below conglomerates) three miles northeast of Siswan, Upper Siwalik India. After comparing the molar morphological parameters of JU/DG/VPL/9002, with all Indian *Stegodon* species, the specimen shows close affinity to *Stegodon insignis* and tentatively referred as *Stegodon cf. Stegodon insignis* Falconer and Cautley

Age and preservation of recovered *Stegodon* specimen

The specimen under study was recovered from the mudstone horizon underlying the geochronological dated (2.48 my) volcanic ash bed (Ranga Rao *et al.*, 1988) exposed at Anandpur village which is the extension of Barakhetar–Uttarbehani ash bed. This volcanic ash bed is a time marker horizon in the Upper Siwalik and exposed in the Siwalik of Jammu at least in eighteen localities having same strike (East- West direction). Bhat *et al.* (2008) discussed the origin of these ash beds and established four palaeo-lakes within 45 km based on the facies study of ash bed and associated mudstone horizons. The associated mudstone horizons also preserved/contain a good assemblage of micro-fauna (ostracodes, gastropods, fishes, rodents) and flora (charophytes) species. The four established palaeolakes are 1. Dora-Karju Tiba, 2. Kherdi- stonywaste-Anandpur, 3. Uttar Behani –

Barakheta-Mandal, and 4. Khanpur – Kamini. These palaeo-lakes spreads in 2 to 7 km area and 5-6 km deep. The present collection is from the section of Kherdi-Stonywaste-Anandpur Palaeo-lake. As the elephants having habitat of living both in terrestrial as well as water bodies and spends sometime of their life in fresh water bodies. The recovery of specimen from the Kherdi-Stonywaste-Anandpur Palaeo-lake sections underlying the ash bed indicates that the death of *Stegodon* Cf. *Stegodon insignis* (specimen under study) might be due to the volcanic ash bed and the specimen preserved in the palaeo-lake sediments. The mudstone horizons underlying the ash bed are very rich in microfauna and flora than the mudstone horizon overlying the ash beds and also have different species. A good number of ichnospecies also collected within these ash beds. This indicates that the preservation might be due to spreading of ash fall deposits. Various author dated these volcanic ash beds from time to time (Yokoyama *et al.*, 1987, Ranga Rao *et al.*, 1988, Agarwal *et al.*, 1993), but the ash bed dated (2.48 m.y.) by Ranga Rao *et al.*, (1988) may be reliable which is coincide with the Gauss-Matuyama boundary. This ash bed many author consider as equivalent to Plio-Pleistocene boundary in Indian Siwalik.

Origin, migration and distribution of *Stegodon*

Fig.3: Distribution of *Stegodon* fauna recovered from the Indian subcontinent from time to time.

The origin of *Stegodon* is the topic of debate among the palaeontologists. Earlier it was believed that the *Stegodon* first originated in the Asian continent and migrated later to other continents. The earliest known *Stegodon* is from the northern China (upper Mauhi Formation) which was dated 5.5 to 6 Ma. At the same time the first appearance of *Stegodon* in the Western Rift valley and the Middle Awash having ages 4-6 Ma and 5.5 Ma

respectively. However, the recent discovery of *Stegodon* from the geochronologically dated Mpsida beds (dated approximately 6.5 Ma) of Tugen Hills, Kenya may shift the place of origin of *Stegodon* from Asian continents to African Continent (Sanders, 1999). The general opinion of palaeontologists is that *Stegodon* was the species of Asian continent but a few authors are of the opinion that the central place of origin of *Stegodon* was Africa and later dispersed to the Middle East and Southern Asia. Based on the cladistic studies, the origin of *Stegodon* initially was African (Kalb *et al.*, 1996) but the frequency of occurrence of *Stegodontax* in Africa was rare than the Asia. *Stegodon licenti* is the most primitive form from Asia and its dental characters have an intermediate position between *Steglophodon pseudolatineds* and *Stegodon zydanski*. *Stegodon* is the sister cousins of genus *Steglophodon*.

In Late Miocene-Early Pliocene, expansion of the *Stegodon* took place in Africa and the same time the *Stegodon* taxa were well flourished, phylogenetically diversified and abundant in Asia and became a dominant member of Asian fauna (Saegusa, 1996). The elephant fauna did not migrate from Africa until Middle Pliocene. The recovery of *Stegodon* with early elephant's fauna in South Africa implies that *Stegodon* and early elephants ecologically co-existed. Brachyodonty type of molar in *Stegodon* indicates browsing or mixed type of feeding in forest environment (Janis, 1986). The disappearance of the *Stegodon* from African continent was due to significant increase in C4 biomass during the Late Pliocene. In Indian subcontinent the oldest record of the *Stegodon* (*Stegodon clifti*) from the Dhokpathan Formation (Potwar/ Hasnot), Middle Siwalik, Pakistan. The distribution of *Stegodon* fauna recovered from the Indian subcontinent by authors from time to time is given in the Fig.3.

CONCLUSION

The *Stegodon cf. Stegodon insignis* (baby) recovered from the mudstone horizon underlying the geochronological dated (2.48 my) volcanic ash bed at Anandpur section which is the extension of Barakheta-Uttarbaini section indicates that the specimen is not younger than ash bed. As the Anandpur section was the marginal part of the Kherdi-Stony waste - Anandpur palaeo-lake and the recovery of *Stegodon* underlying the ash bed indicate that the death might be due to ash fall.

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