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FIRST FOSSIL MARSUPIALS FROM INDIA: EARLY EOCENE *INDODELPHIS* N. GEN. AND *JAEGERIA* N. GEN. FROM VASTAN LIGNITE MINE, DISTRICT SURAT, GUJARAT

SUNIL BAJPAI[1*], VIVESH V. KAPUR[1], J. G. M. THEWISSEN[2], B. N. TIWARI[3] and DEBASIS P. DAS[1]

[1] DEPARTMENT OF EARTH SCIENCES, INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE 247 667, INDIA
[2] NORTHEASTERN OHIO UNIVERSITIES COLLEGE OF MEDICINE, ROOTSTOWN, OH 44272, USA
[3] WADIA INSTITUTE OF HIMALAYAN GEOLOGY, DEHRADUN 248 001, INDIA

ABSTRACT

We report the discovery of fossil marsupials (Didelphidae: Mammalia) from India, based on well-preserved lower molars of two taxa (*Indodelphis luoi* n. gen. and n. sp. and *Jaegeria cambayensis* n. gen. and n. sp.) from the early Eocene (middle Ypresian, approximately 52 Ma) deposits of Vastan Lignite Mine, District Surat, Gujarat, western India. These species probably represent the oldest known record of Cenozoic marsupials from Asia, and they occur in association with a diverse land mammal fauna comprising perissodactyls, artiodactyls, insectivores, proteutherians, apatotherians, bats, rodents, and several other taxa currently under study.

Key words: Eocene, Metatheria, Didelphidae, India-Asia collision

INTRODUCTION

Living pouched mammals are restricted to Australia and the Americas, and are not included in the mammal fauna of Asia. Their fossil record in Asia is also extremely poor, and there are only a few known localities in the whole continent that have yielded Cenozoic marsupials. In the Indian subcontinent, the only known marsupial is a lower molar of an unnamed didelphid from the early or middle Eocene Kuldana Formation of Pakistan, described by one of us (Thewissen *et al.*, 2001). Elsewhere in Asia, known Cenozoic taxa include the late Eocene and early Oligocene *Asiadelphis* from Kazakhstan (Benton, 1985; Gabunia *et al.*, 1990; Emry *et al.*, 1995); an unnamed middle Eocene taxon from China (Qi *et al.*, 1991, 1996); an unnamed herpetotheriine didelphid from the early to middle Eocene of Turkey (Kappelman *et al.*, 1996; see also Maas *et al.*, 1998); a paradectine didelphid from the middle Miocene of Thailand (Ducrocq *et al.*, 1992; Mein and Ginsburg, 1997) and a paradectine didelphid from the early Miocene of China (Storch and Qiu, 2002).

As part of our ongoing studies of Eocene vertebrates from the lignite mines of western India (e. g. Samant and Bajpai, 2001; Bajpai and Thewissen, 2002; Rage *et al.*, 2003; Bajpai and Kapur, 2004; Bajpai *et al.*, this volume), we report the first marsupials from India from the Vastan Lignite Mine, District Surat, Gujarat. To the best of our knowledge, this find represents the oldest known Cenozoic marsupials from Asia. The

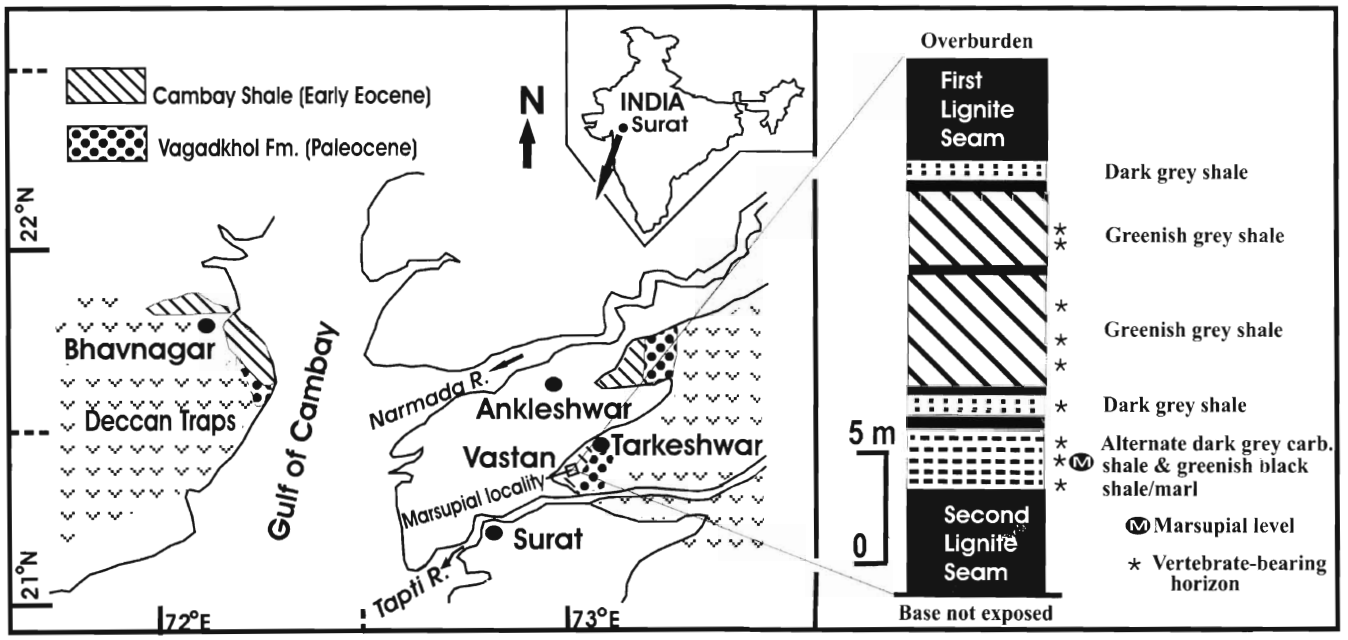


Fig. 1. Location and geological map of the study area (left); lithostratigraphic column showing position of the marsupial-yielding horizon in sequence.

* Corresponding author: Fax: 0091-1332-273560; Email: sunilfes@iitr.ernet.in

marsupial-bearing horizon is a dark grey siltstone that occurs between the first and second lignite seams in the mine (see locality and stratigraphic information in fig. 1) and its age is constrained by the early Eocene foraminifer *Nummulites burdigalensis* which occurs about 10 m above the marsupial horizon. This foraminifer corresponds to the Shallow Benthic Zone SB 10, indicating a middle Ypresian age (ca. 52 Ma, Serra-Kiel *et al.*, 1998) for the marsupial level. Mammals associated with the Vastan marsupials include perissodactyls, artiodactyls, insectivores, proteutherians, apatotherians, bats, rodents, and several other taxa that are currently under study.

The entire collection described in this paper is housed in the Vertebrate Paleontology Laboratory, Department of Earth Sciences, Indian institute of Technology, Roorkee (under the catalogue numbers IITR/SB/VLM).

SYSTEMATIC PALAEONTOLOGY

Order **Didelphimorphia** Gill, 1872

Family **Didelphidae** Gray, 1821

Subfamily **Peradectinae** Crochet, 1979

Genus ***Indodelphis*** n. gen.

Type species: *I. luoi* n. sp.

Derivation of name: in reference to the location of the fossil and to its systematic affinities.

Diagnosis: Talonid cusps low, subequal in size; convex paracristid; talonid wide and deep, cingulid present only on the labial base of paraconid.

Age and Distribution: early Eocene of India.

Indodelphis luoi n. sp.

(Plate I, figs. 1-4)

Derivation of name: Named for Dr. Zhe-Xi Luo, in recognition of his contribution to our understanding of marsupial origins.

Diagnosis: Generic and specific diagnosis cannot be distinguished at present.

Holotype: IITR/SB/VLM/ 595 (isolated left lower molar)

Description: The molar is 1.59 mm long and 0.71 mm wide in the talonid region. The talonid is approximately equal in length to trigonid but is wider and considerably lower in height. The trigonid basin is relatively small, but with fairly wide lingual opening. Of the trigonid cusps, the protoconid is higher than metaconid, and the paraconid is much smaller than the other trigonid cusps. The paraconid is centrally situated (i.e. at the trigonid midline) and directed markedly anteriorly. The paracristid is somewhat convex in labial view.

The talonid basin is conspicuously deep and wide (more or less circular in outline) with three low cusps of more or less same height. The hypoconulid and entoconid are strongly joined (twinned) without any sharp notch. The hypoconulid is oriented nearly vertically. The cristid obliqua ascends the posterior wall of the trigonid slightly but terminates bucally, well below the protoconid notch. The cingulid is present only on the anterolabial base of the tooth.

Remarks: This tooth can be identified as a didelphid marsupial on the basis of a lingually open trigonid with a small, anterolingual paraconid, and the twinned entoconid/ hypoconulid (Crochet, 1980). Didelphids include the two Eocene subfamilies (Peradectinae and Herpetotheriinae), and the differences between these subfamilies have been discussed by Krishtalka and Stucky (1983) and Korth (1994).

Indodelphis is a peratherine based on the similarity in size of entoconid and hypoconulid, and the absence of a notch between them. In this respect, the new species is clearly distinct from Eocene didelphids from Turkey (Kappelman *et al.*, 1996) and Pakistan (Thewissen *et al.*, 2001).

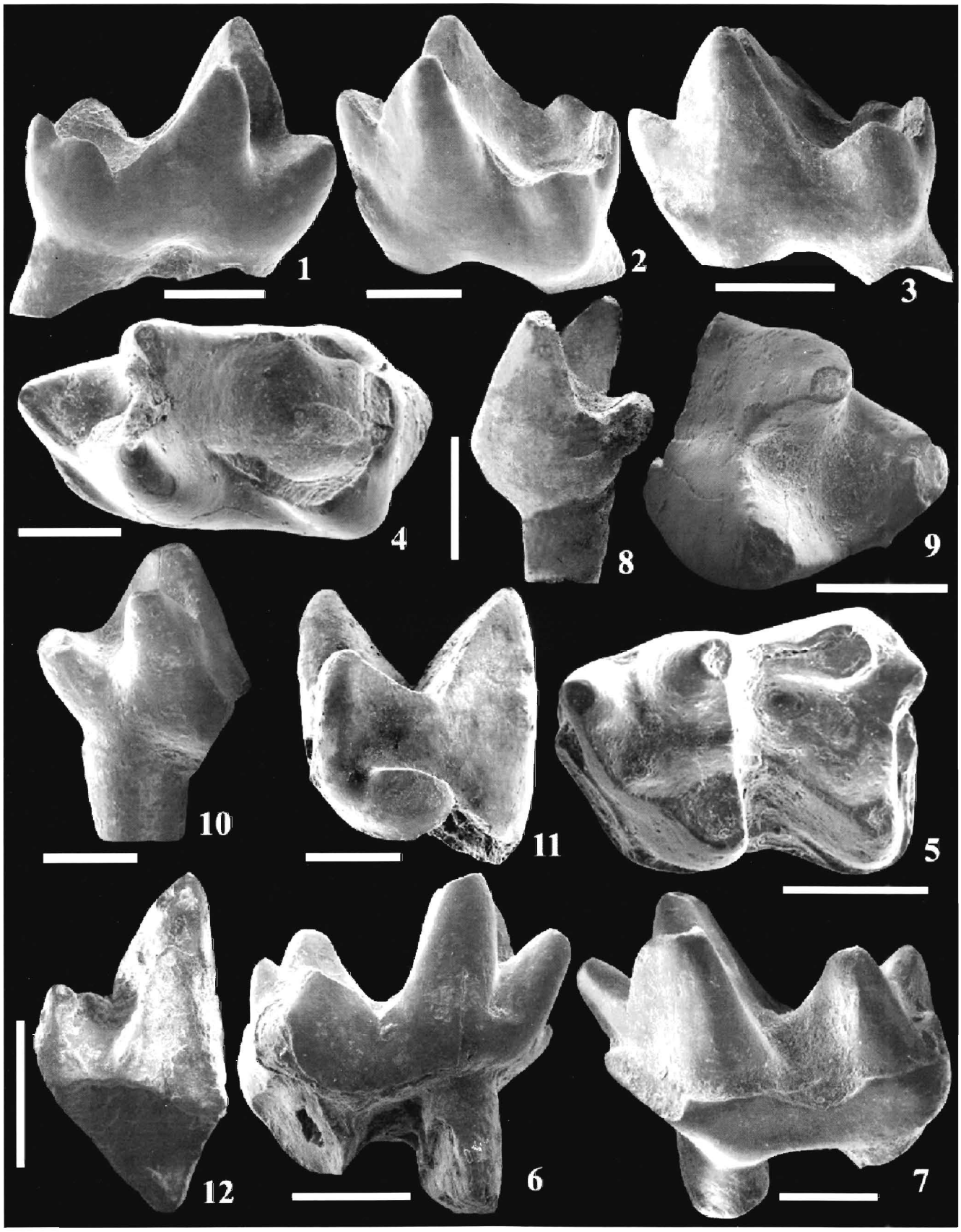
Type Locality: Vastan Lignite Mine, Taluka Mangrol, District Surat, Gujarat, India.

Type Horizon: Cambay Shale, *N. burdigalensis* Zone (SBZ 10)

EXPLANATION OF PLATE I

(scale bar equals 300μm for fig.9; 400μm for figs. 4, 10, 11; 500μm for figs. 1, 2, 5, 6; 600 μm for 3, 7, 8; 700μm for fig. 12)

1. ***Indodelphis luoi*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 595), lingual view.
2. ***Indodelphis luoi*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 595), labioocclusal view.
3. ***Indodelphis luoi*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 595), labial view.
4. ***Indodelphis luoi*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 595), occlusal view.
5. ***Jaegeria cambayensis*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 585), occlusal view.
6. ***Jaegeria cambayensis*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 585), lingual view.
7. ***Jaegeria cambayensis*** n. gen. & n. sp., left lower molar, holotype (IITR/SB/VLM 585), labial view.
8. ***Jaegeria cambayensis*** n. gen. & n. sp., right lower molar trigonid (IITR/SB/VLM 602), labial view.
9. ***Jaegeria cambayensis*** n. gen. & n. sp., right lower molar trigonid (IITR/SB/VLM 602), occlusal view.
10. ***Jaegeria cambayensis*** n. gen. & n. sp., right lower molar trigonid (IITR/SB/VLM 602), lingual view.
11. ***Jaegeria cambayensis*** n. gen. & n. sp., left lower molar trigonid (IITR/SB/VLM 603), anterior view.
12. ***Jaegeria cambayensis*** n. gen. & n. sp., right lower molar trigonid (IITR/SB/VLM 604), lingual view.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Subfamily **Herpetotheriinae** Trouessart, 1879

Genus ***Jaegeria*** n. gen.

Type species: *Jaegeria cambayensis* n. sp.

Derivation of name: Named for Prof. J. J. Jaeger in recognition of his contributions to mammalian palaeontology.

Diagnosis: small didelphid with pronounced proto- and paracristids; hypoconid much larger than other talonid cusps in contrast to *Indodelphis*; large, pyramidal protoconid.

Age and Distribution: early Eocene of India.

Jaegeria cambayensis n. sp.

(Plate I, figs. 5-12)

Referred Material: IITR/SB/VLM/602 (right molar trigonid); IITR/SB/VLM/603 (left molar trigonid); IITR/SB/VLM/604 (right molar trigonid).

Derivation of name: in reference to the Cambay Shale, the formation that yielded the fossil.

Diagnosis: Generic and specific diagnosis cannot be distinguished at present.

Holotype: IITR/SB/VLM/ 585 (left lower molar)

Description: The holotype measures 1.40 mm long and 0.93 mm wide (talonid). The talonid is wider than trigonid and the trigonid-talonid height differential is much reduced as compared to *Indeodelphis luoi* (IITR/SB/VLM 595). The protoconid is large, pyramidal in shape. Its tip is broken off, but it must have been slightly higher than metaconid. The larger size of the protoconid is much more clearly seen in specimens such as IITR/SB/VLM/602 (Pl. I, figs. 8-10). The paraconid is small, situated at the anterolingual corner of the tooth and is directed markedly antero-lingually. It is aligned with metaconid and entoconid, as opposed to the much more labially positioned paraconid in the marsupial species described above (IITR/SB/VLM 595).

The talonid has three cusps with hypoconid being the largest and the hypoconulid smallest in size Seen labially, the hypoconid is oriented parallel to the protoconid. The entoconid tip is broken but it was evidently larger and higher than hypoconulid. The hypoconulid is located posterolingual to entoconid but the two cusps are strongly joined ("twinned"). The hypoconulid is somewhat posteriorly directed, giving rise to a notch between it and the entoconid. The proto- and paracristids are markedly strong. The cristid obliqua attaches to the trigonid below the protocristid notch, unlike in *Indodelphis luoi* (IITR/SB/VLM 595) where it meets the trigonid much more bucally. Strong cingulids are present on all sides except the lingual.

Remarks: This species is here assigned to the Didelphidae mainly because of an anteriorly directed paraconid, a twinned entoconid- hypoconulid and a protoconid which is larger and also slightly higher than metaconid. It is referred to herpetotheriines based on the height of the entoconid, which is higher than the hypoconulid. The new species differs from the unnamed didelphid described from the Eocene Kuldana Formation of Pakistan (Thewissen *et al.*, 2001) in certain respects. In the latter, the entoconid is much larger and similar in height to hypoconid, unlike the Vastan molar where the hypoconid is much larger than the other talonid cusps. Also, the lingual opening in the trigonid is smaller in the specimen as compared to the Kuldana marsupial. In addition, the new species differs from the Pakistani herpetotheriine in having a smaller paraconid. *Jaegeria cambayensis* differs from the unnamed herpetotheriine from Turkey (Kappelman *et al.*, 1996) in the more lingually placed protoconid.

Type Locality: Vastan Lignite Mine, Taluka Mangrol, District Surat, Gujarat, India.

Type Horizon: Cambay Shale, *N. burdigalensis* Zone (SBZ 10)

DISCUSSION

The material described in this paper does document the presence of Eocene marsupials in South Asia. The most diagnostic difference in lower molar morphology between didelphids and placental mammals is the anterorly directed paraconid and the lingually wide open trigonid (Crochet, 1980). Both *Indodelphis* and *Jaegeria* display this feature as well as ancillary features such as the high protoconid and twinning of entoconid and hypoconulid (Crochet, 1980). It is thus evident that marsupials were much more widely distributed in the early Tertiary than the fossil record suggested until now. Additional specimens were recovered while this paper was well advanced and their study is expected to help assess the phylogenetic status of the Indian marsupials.

Biogeographically, an important question to be addressed is whether the Eocene paradectine and herpetotheriine marsupials from India, as well as the previously known herpetotheriine marsupial from the Eocene of Pakistan (Thewissen *et al.*, 2001), represent holdovers from an erstwhile Gondwana connection or whether they indicate dispersal from the north following India-Asia contact. This issue needs to be addressed in the light of recent discoveries of Cretaceous marsupials in Madagascar (Krause, 2001; but see Averianov *et al.*, 2003, for an alternative viewpoint) and China, the latter representing the oldest known record of a metatherian (Luo *et al.*, 2003; see also Cifelli and Davis, 2003).

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