possible to close the circle of correlation (and thus to test the pollen and vertebrate correlations against each other) because of the uncertain relation of the type Sparnacian to marine microfossil zonations (*32, 34, 40*). Because it has proved exceptionally difficult to establish correlations between the type Sparnacian and other sections, many authors prefer to correlate to a datum based on nannoplankton (NP9/NP10), planktic foraminifera (P6a/P6b), and dinoflagellates (*Apectodinium hyperacanthum*/*Wetzeliella astra*). Since fossil pollen now provides a link between land mammal succession and these marine microfossil zonations, it is preferable to recognize the marine datum rather than to continue attempting correlation with a less precise and less useful Paleocene/Eocene boundary based on the type Sparnacian of the Paris Basin.

Precise correlation of terrestrial strata on different continents is important for evolutionary and paleobiogeographic syntheses. Recent studies on centers of origin and evolution for early Tertiary mammals (*10, 11*) and on the effect of early Tertiary climates on the evolution and migration of many lineages of plants and animals (*30*) have stimulated interest in the detection of diachronous events in the fossil record. Too often paleobiologists are forced into the logically tenuous position of studying purportedly diachronous events in the same group of organisms that they use for correlation. Precise, mutually agreed upon boundaries that are based on a broad array of taxonomic groups are a necessary framework for recognizing diachronous evolutionary and migrational events in the fossil record.

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Cretaceous-Paleocene Terrestrial Faunas of India: Lack of Endemism During Drifting of the Indian Plate

Abstract. *Recent paleontological investigations of six sections fringing the Deccan volcanic outcrops of the Indian peninsula indicate that terrestrial faunas during the Cretaceous-Paleocene transition lacked the endemism predicted by geophysical models of an oceanically isolated Indian subcontinent. At the generic and familial level there is a close correspondence between the Cretaceous vertebrates of peninsular India, Africa, and Madagascar. This suggests that a dispersal corridor, consisting of presently submerged aseismic elements (the Mascarene Plateau and the Chagos-Laccadive Ridge), existed between these landmasses about 80 million years ago as India drifted close to eastern Africa.*

In geophysical models the Indian landmass is envisaged as a northward-drifting, isolated subcontinent before its collision with the Tibetan Block (*1, 2*). Until recently, paleontological data on terrestrial faunas during India's phase of isolation (Cretaceous, Paleocene, and Lower Eocene) were not available to support the hypothesis that biotic endemism resulted from the supposed isolation. During the past 4 years, however, the subject has been reexamined (*3, 4*) in light of studies of several previously known and newly discovered localities (*4, 5*) fringing Deccan Basalt outcrops in peninsular India (Fig. 1).

The material collected from measured sections represents a diversified vertebrate fauna from a coastal plain environment. The faunal list is given in Table 1. Associated fossils in most localities include a rich assemblage of charophytes (*Microchara, Platychara*), cyprid ostracods, unionid pelecypods, and pulmonate gastropods. In at least two central Indian localities (Jabalpur and Asifabad), the presence of shallow-water foraminifera has been recorded (*4*). The paleontological data on peninsular India are therefore now fairly extensive, and they suggest not a general endemism but rather a cosmopolitan distribution at the generic level.

Although Cretaceous-Paleocene taxa in peninsular India have a wide distribution, they appear to be closest to those from the same time interval in Africa and Madagascar. This affinity is consistent with geophysical models (*1*) that envisage a contact with the eastern coast of Africa that was maintained much later than that with Australia and Antarctica, for which an Early Cretaceous separation is considered likely. Striking similarities are noted among African and Indian fish, turtles, and dinosaurs. The coastal

Table 1. Cretaceous-Paleocene fauna from a coastal plain environment of drifting India. The numbers given in parentheses are keyed to the localities shown in Fig. 1.

Class Pisces
- *Dasyatis* (3, 5, 6)
- *Rhinoptera* (3, 5, 6)
- Myliobatids (5, 6)
- Pycnodonts (3, 5, 6)
- *Lepisosteus* (3, 5, 6)
- Cf. *Belonostomus* (3, 6)
- Cf. *Amia* (3)
- *Lepidotes* (3)
- *Phyllodus* (3)
- *Arius* (3)
- Various tetraodonts (*Stephanodus, Eotrigonodon, Indotrigonodon*) (?2, 3, 5, 6)
- Otolith-based percoid genera (*Kuhlia, Epinephelus*) (3)
- Osteoglossids (*Pharaeodus*) (3, 6) (3, ?6)

Class Amphibia
- Pelobatid frogs (3, 5, 6)

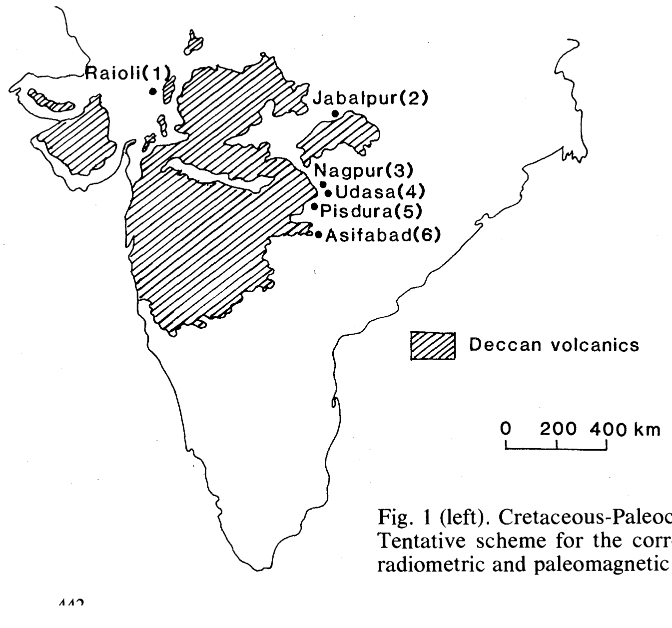
Class Reptilia
- Booid snakes (3, 5)
- Anguid lizards (3)
- Pelomedusid turtles (3–6)
- Crocodiles (3, 5)
- Saurischian dinosaurs (mainly titanosaurids) (1–6)
- Eggshell fragments (mainly dinosaurian; others of uncertain affinity) (1–3,6)

Class Mammalia
- Primitive mammal (cf. Symmetrodonta)

fish faunas from the Cretaceous-Paleocene of Niger (*6, 7*) are identical at the generic level to taxa from the Indian peninsula. Common forms include *Dasyatis, Igdabatis, Rhombodus, Pycnodus, Lepisosteus, Lepidotes, Amia, Enchodus*, and *Stephanodus*. One of the oldest occurrences of pelomedusid turtles was recorded in the Maestrichtian of Pisdura (*8*). Recently, a slightly older locality was reported from the Senonian of Niger and the Early Cretaceous of the Sahara (*7*). Pelomedusids probably migrated from Africa into India during the Upper Cretaceous and were one of the most widely distributed turtle families in the Indian Early Paleogene, both in peninsular India and in the Lesser Himalayas. Other typical holarctic genera include *Lepisosteus, Pharaeodus*, pelobatid frogs, anguid lizards, and booid snakes, and suggest the existence of a dispersal corridor before the Paleocene. Upper Cretaceous dinosaurian faunas of India, Africa, and Madagascar are similar at the generic level with a common species (*Laplatosaurus madagascarensis*). This strong affinity was noted previously (*8, 9, 10*).

Efforts have been made to determine the age of the fossiliferous sedimentary sequences associated with the Deccan Basalts on the basis of radiometric dating, paleomagnetic geochronology (*11*), and faunal assemblages (*4*) (Fig. 2). Potassium-argon dates for the basalts are often anomalous and are considered to be underestimates (*12*). The most comprehensive study yet conducted with radiometric and paleomagnetic dating in the Nagpur area (*11*) suggests that the Nagpur ossiferous horizon (Takli Formation) represents an interval between anomalies 26 and 31, as the overlying Nagpur basalts give a (minimum) age of 57 ± 2.9 million years. This section (section 3) is the most thoroughly studied of all the localities investigated here. The Nagpur basalts are the oldest known of the Deccan volcanics and represent the Nagpur reversed polarity epoch (*11*). The stratigraphically oldest basalt probably corresponds to anomaly 30 or 31 because younger ages (anomaly 26) are not consistent with paleontological data. The Takli Formation would then be at or close to the Cretaceous-Tertiary boundary. The presence of dinosaurs in this horizon (*13*), traditionally dated as Paleocene in age on the basis of megafloral (*14*) and charophyte (*15*) evidence, suggests two possible explanations. Either dinosaurs survived into the earliest Tertiary in India as predicted by Van Valen and Sloan (*16*) or the Takli Formation represents the uppermost Cretaceous. The biostratigraphic correlation of the other sections illustrated in Fig. 2 with the Nagpur section has been done solely on the basis of the vertebrate and charophyte assemblages recovered from the inter- and infrabasaltic sedimentary beds. The Raoili section (section 1) is still being worked out (*5*), but the prolific vertebrate faunas indicate a correlation with the ossiferous horizons of section 2 at Jabalpur (*17*), section 4 at Udasa (*18*), and section 5 at Pisdura (*19*). Section 6 at Asifabad, although coeval with the corresponding ossiferous horizon in section 3, includes a greater percentage of brackish water and marine faunal elements (*4*). It should be emphasized that the biostratigraphic correlations outlined in Fig. 2 are diagrammatic representations of the present paleontological findings; precise physical dating methods have yet to be rigorously applied to fossiliferous localities other than section 3.

The overall congruency of geophysical and magnetic anomaly studies showing India as a drifting island subcontinent for most of the Cretaceous and the Paleo-



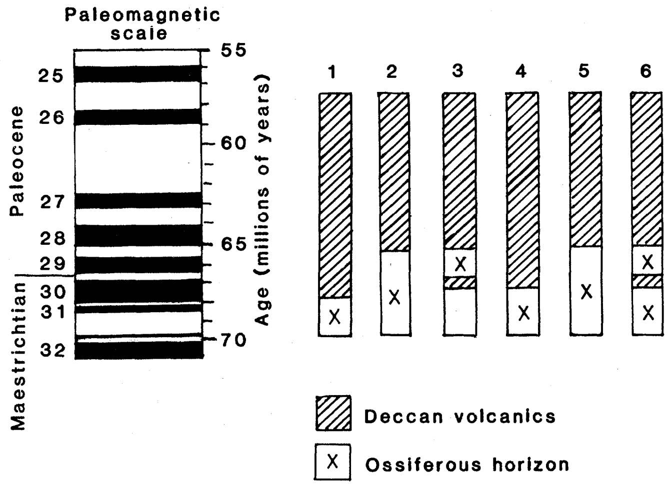


Fig. 1 (left). Cretaceous-Paleocene terrestrial vertebrate localities of peninsular India. Fig. 2 (right). Tentative scheme for the correlation of the inter- and infrabasaltic sedimentary sequences for which radiometric and paleomagnetic data are available with the Nagpur section.

cene makes it difficult to explain the cosmopolitan nature of the Indian terrestrial faunas during this period. These findings suggest the likelihood of a migration from eastern Africa sometime during the Upper Cretaceous (about 80 million years ago) as India drifted close to the east coast of Africa and Madagascar. A possible filter corridor from Africa may be found in two aseismic ridges, the Mascarene Plateau and the Chagos-Laccadive Ridge. Deep-Sea Drilling Project (DSDP) site 237 bottoms in shallow-water Paleocene sediments and has a bathymetry (less than 100 m) similar to that estimated for Paleocene sediments at DSDP site 219 on the Chagos-Maldive Ridge. Although there are no data for the Cretaceous, it is plausible that both aseismic ridges may have provided the necessary dispersal corridor, as these elements are considered to have been joined together before initial spreading along a transform fault (*20*). The Maldive Ridge probably fractured away from the west coast of India before the Paleocene (*21*), and would have formed a suitable extension of the same dispersal route.

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A Conformationally Constrained Vasopressin Analog with Antidiuretic Antagonistic Activity

Abstract. *Application of information derived from a three-dimensional model of vasopressin bound to its antidiuretic receptor resulted in the design and synthesis of a bicyclic vasopressin analog,* [*5,8*-cyclo(*1*-β-*mercaptopropionic acid,2-phenylalanine,5-aspartic acid,8-lysine)*]*vasopressin. The analog acts as an antagonist of the antidiuretic activity of vasopressin.*

Through integration of data from structure-activity and conformation studies of peptide hormones, models of the biologically active conformation of a peptide while bound to a receptor responsible for a specific activity can be developed. Such models may be helpful in designing peptide analogs with high and specific biological activity, and, with an adequate hypothesis of the interaction of the receptor with the "binding elements and active elements" (*1*) present on the peptide, it may also be possible to design competitive inhibitors. In the study reported here, a working model of the biologically active conformation of the neurohypophyseal hormones arginine vasopressin and lysine vasopressin (*2, 3*),

$$\overline{\text{Cys}^1\text{-Tyr}^2\text{-Phe}^3\text{-Gln}^4\text{-Asn}^5\text{-Cys}^6}\text{-}$$
$$\text{Pro}^7\text{-(Arg}^8\text{ or Lys}^8\text{)-Gly}^9\text{-NH}_2$$

was used to design a bicyclic vasopressin analog, [5,8-*cyclo*-(1-β-mercaptopropionic acid,2-phenylalanine,5-aspartic acid,8-lysine)]vasopressin (bicyclic MPA-LVP) (Fig. 1).

The hypothetical biologically active conformation of vasopressin responsible for the antidiuretic activity of the hormone was described previously (*2*). The utility of this model has been demonstrated clearly by the design and synthesis of vasopressin analogs with extraordinarily high and specific antidiuretic agonistic potency (*4, 5*). This model suggested that the carboxamide group of asparagine in position 5 was a key active element in determining intrinsic activity or efficacy. Furthermore, it suggested that the basic moiety on the side chain of the residue in position 8 (lysine or arginine), in close proximity to the asparagine carboxamide, formed another active element. These two elements act cooperatively for maximum efficacy (Fig. 2). Modifications that perturb the orientation and cooperativity of these elements might be expected to lead to antidiuretic inhibitors, provided that the perturbations do not also reduce binding. Joining the side chains of the residues at positions 5 and 8 could theoretically eliminate cooperativity while maintaining necessary side-chain orientations for binding.

Synthesis of the protected peptide intermediate was accomplished on a poly-*N*-acrylylpyrrolidine resin (*6*). *N*-*tert*-butyloxycarbonylglycyl-(4-oxymethyl)benzoic acid (*7*) was quantitatively attached to the resin through a norleucine residue that had been introduced as an internal

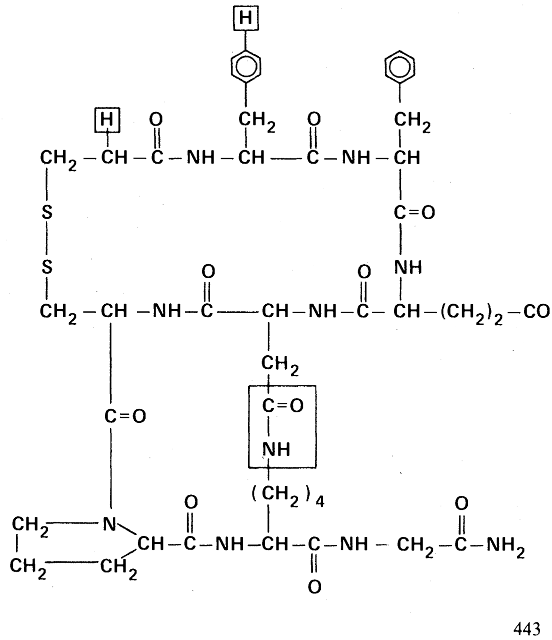

Fig. 1. Structure of bicyclic MPA-LVP with the modifications that make it different from lysine vasopressin highlighted by boxes.