GONDWANAN DINOSAURS OF INDIA: AFFINITIES AND PALAEOBIOGEOGRAPHY

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The record of Indian dinosaurs is now well known and extends from Late Triassic to the terminal Cretaceous. The Indian dinosaurs are based on fragmentary cranial, skeletal and egg material which is a cause of some uncertainty in the analysis of their taxonomic affinities, age and palaeobiogeography. The Indian dinosaurian record starts with the Triassic Maleri Formation, which yields *Alwalkeria maleriensis*, a coelurosaur. The overlying Dharmaram Formation contains phytosaurs, aetosaurs, plateosaurids and a sphenosuchid. The early Jurassic Kota Formation has yielded numerous bones (cranial and postcranial) of *Barapasaurus tagorei*, besides semionotid fishes, coelacanths, pleurosaurs, crocodiles and mammals. The Cretaceous dinosaurian record is from sedimentary sequences associated with the Deccan volcanics and is dominated by skeletal remains of titanosaurid sauropods and theropods, such as *Indosuchus raptorius* and *Indosaurus matleyi*. The Kallamedu Bone Bed (Ariyalur Formation) has yielded bones and a tooth of *Megalosaurus*. The cranial and postcranial skeleton of a stegosaur *Dravidosaurus blanfordi* is known from the Trichinopoly Group. Khosla & Sahni (1995) have classified Indian dinosaur eggs and eggshell fragments into eight new oospecies (in the oofamilies Megaloolithidae and Subtiliolithidae): *Megaloolithus cylindricus, M. jabalpurensis, M. mohabeyi, M. baghensis, M. dholiyaensis, M. walpurensis, M. padiyalensis* and *Subtiliolithus kachchhensis*. Besides these Late Cretaceous eggshells, footprints are known from the Bhuj Formation of Early Cretaceous age (Ghevariya & Srikarni, 1990). Coprolites of dinosaurs and (probable) chelonians are known from the Late Cretaceous of Pisdura, and include four categories of ribbed and non-ribbed forms. The palaeobiogeographic analysis of the Indian dinosaurs implies they are part of a cosmopolitan distribution. However, migrations through an earlier Madagascan connection and through island arcs in the Cretaceous (represented by Dras volcanics) and earlier collision arcs and microplates in Late Permian to Cretaceous (represented by northernmost Gondwana fragments of Tibet, Iran, Iraq and Afghanistan) led to an influx of some taxa. These paths of migration are significant in explaining the cosmopolitan character of the Indian biotas and their similarities to Laurasian faunas during the drift of the Indian Plate.
☐ *India, dinosaurs, Mesozoic, tracks, dinosaur nests, eggs.*

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Dinosaur remains in India are found in the Triassic-Cretaceous sequence of peninsular India (Table 1), however Middle Jurassic-Middle Cretaceous gaps are quite significant. In this context, the Pranhita-Godavari valley, where a thick continental vertebrate-rich sequence of Late Permian-Cretaceous age is exposed, has assumed considerable significance as a site for Gondwanan dinosaurs.

While the Pranhita-Godavari Valley (Fig. 1) represents a repository of dinosaurs of Triassic-Jurassic age, the younger terminal Cretaceous dinosaur fauna is most diverse. It occurs along the Narmada Valley of central India, associated with the Lameta Formation and is spread over more than 10,000 sq. km., below the Deccan volcanosedimentary sequence (Sahni et al., 1994, Fig. 2). In addition, Cretaceous dinosaurs also occur towards the south, associated with the Ariyalur Formation.

TRIASSIC

The oldest record of Indian dinosaurs comes from the Late Triassic Maleri Formation, which is exposed near the village Maleri (near Tandur) in the district Adilabad, Andhra Pradesh. Lithologically, red clays are abundant, along with lime-pellet rocks (calcirudites, calcarenites) and quartzose sandstones (Kutty & Sengupta, 1989).

The biotic elements of Maleri Formation include vertebrates, coprolites, invertebrates and plants. Dominant in the Lower Maleri, is *Alwalkeria maleriensis*, which constitutes the earliest Indian dinosaur (Chatterjee, 1987) and is based on imperfectly known fragmentary material, a partial skull, vertebrae, a femur and astragali. It is referred to the basal theropods, belonging to a group of slightly built predaceous dinosaurs.

The overlying Dharmaram Formation is composed of a basal thick sandstone followed by more sandstones and clay beds. The sandstones resemble the Maleri sandstones, but are more coarse-grained and gritty (Kutty et al., 1987). The lower part of the Dharmaram Formation — besides the occurrence of the fish *Xenacanthus* and *Ceratodus* — is characterised by the presence of a phytosaur (*Nicrosaurus*), dominant aetosaurs and a small prosauropod (Kutty & Sengupta, 1989). The Upper Dharmaram Formation, on the other hand, is far richer and contains a large plateosaurid, an ornithischian and a sphenosuchid (Kutty, 1969; Kutty et al., 1987). Although as the fauna remains undescribed as yet, a Late Norian-Rhaetian age is preferred by most workers for this fauna.

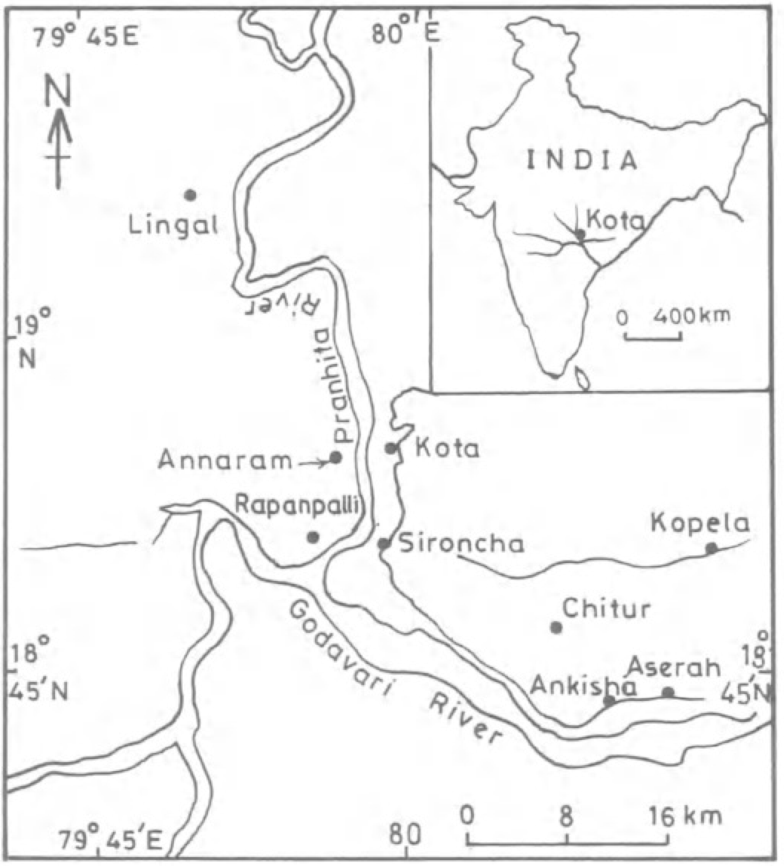

FIG. 1. Map of Pranhita-Godavari Valley with fossil- bearing localities (after Jain et al., 1975).

JURASSIC

The continental Kota Formation, of Early Jurassic age, lies conformably above the Dharmaram Formation and in turn is overlain by Gangapur Formation of Early Jurassic age (Kutty et al., 1987). The stratotype of this formation is named after Kota village, on the eastern bank of the Pranhita River. This formation has provided a vast amount of information about its exceedingly rich continental fauna, comprising fishes, reptiles, mammals, freshwater ostracodes, conchostrachans and land insects (Kutty et al., 1987).

The lithic units of the Kota Formation are characterised by sandstones (ferruginous arkoses), with cross-bedding, and limestones with desiccation polygons and worm-bored layers (Robinson, 1970; Jain, 1980; Yadagiri & Rao, 1987).

Field work conducted by palaeontologists of the Indian Statistical Institute in the Kota Formation during 1960-61 led to the recovery of about 300 sauropod bones from a bone bed occurring between a sandstone-clay lens. This vertebrate material was assiduously studied by Dr S.L. Jain and his colleagues, who established a new sauropod, *Barapasaurus tagorei*, one of the best known Early Jurassic dinosaurs in the world (Jain, 1975, 1979). A complete mounted skeleton of this dinosaur is displayed at the Geology Museum, Indian Statistical Institute, Calcutta.

Barapasaurus tagorei was a large sauropod with slender limbs, spoon-shaped teeth with coarse denticles, opisthocoelous cervical and anterior dorsal centra, with the other centra platycoelous. Neural spines are not bifurcate and the centra are not cavernous, but have oval depressions in the lateral surface. The ilium possesses a well-developed anterior process, the ischium is relatively slender and rod-like distally and the pubis has a well-developed terminal expansion.

Jain et al. (1979) commented on the level of development of *Barapasaurus*, stating that it is intermediate between the prosauropod stage and that of known sauropods (e.g., the limbs, though graviportal, are slender). The anterior caudals have not developed procoelous centra. The sacrum is narrow, with the pelvic depression small in comparison to length of the pubis. McIntosh (1990) tentatively assigned *Barapasaurus*

TABLE 1. Gondwana stratigraphy of Pranhita-Godavari Valley (modified after Kutty et al., 1987).

LITHO-UNIT, AGE	CONTAINED FOSSILS	LITHOLOGY
Deccan volcano-sedimentary sequences Late Cretaceous	mammals, dinosaurs (titanosaurids), frogs, fishes, charophytes, ostracodes	sandstones, shales, marls, associated with Deccan basalts
Chikiala		ferruginous sandstones conglomerates
Gangapur Early Cretaceous	*Gleichenia, Pagiophyllum Ptilophyllum*	gritty sandstones, pink mudstones, ferruginous sandstones
Kota Early Jurassic	holostean fishes, sauropods, pterosaurs, early mammals	sandstones, siltstones, clays and a limestone band
Dharmaram late Late Triassic	prosauropods	sandstones, red clays
Maleri early Late Triassic	metoposaurs, aetosaurs, phytosaurs, rhynchosaurs	red clays, sandstones, lime-pellet rocks
Bhimaram Sandstone late Middle Triassic	labyrinthodont, dicynodont	sandstones (ferruginous in lower part), red clays
Yerrapalli early Middle Triassic	stahleckeriid, kannemeyeriid dicynodonts	red violet clays, sandstones, pellet rocks
Kamthi Late Permian-Early Triassic	dicynodonts from basal beds	ferruginous, non-felspathic sandstones, purple siltstones

to the Vulcanodontidae (Cooper, 1984) on the basis of the narrow sacrum, deeply furrowed caudals, long forelimbs, apron-like pubis, elongate metatarsals and teeth with coarse denticles.

The associated fauna of the Kota dinosaurs includes semionotid fishes (*Tetragonolepis, Lepidotes, Parapedium*), a coelacanth (*Indocoelacanthus robustus*), a pholidophorid fish (*Pholidophorus*), a pterosaur (*Campylognathoides*) and teleosaurid crocodiles (Kutty et al., 1987; Jain & Roy Chowdhury, 1987). Early Jurassic mammals from the Kota Formation are represented by *Kotatherium, Trishulotherium* and *Indotherium* (Datta, 1981; Yadagiri, 1984; 1985).

CRETACEOUS

SKELETAL MATERIAL. The Indian Cretaceous dinosaur record is associated with the non-marine post-Gondwana sequence of central and western India. This sequence is represented by Lameta Formation, which has received considerable attention for the last 70 years for its fairly extensive dinosaurian fauna. Stratigraphically, the dinosaur-rich vertebrate beds underlie the Deccan Traps, with an aerial extent of more than 10,000 sq. kms. As such, this vertebrate sequence is crucial to the dating and duration of the traps, more so as the Late Cretaceous extinction mechanisms might be related to the eruptions (Courtillot et al., 1986; Buffetaut, 1987).

The stratotype of the Lameta Formation is situated at Lametaghat, near Jabalpur on the banks of Narmada river. The classic dinosaur areas here are Bara Simla Hill and Chui Hill, in addition to Pisdura in Maharashtra. The first detailed account of the geology of the Jabapur area was given by Matley (1921), who prepared an excellent map of the area on a scale measuring 8 inches to a mile, along with a description of various lithic units.

Huene & Matley (1933) described postcranial elements of the titanosaurid sauropods, viz. *Titanosaurus indicus* and *Antarctosaurus septentrionalis* from Bara Simla Hill, and a third sauropod *Laplatasaurus madgascariensis* from Pisdura. From the same locality carnosaurs were also described: *Indosuchus raptorius* and *Indosaurus matleyi*, along with coelurosaurs, such as *Compsosuchus solus, Laevisuchus indicus, Jubbulpuria tenuis, Coeluroides largus, Dryptosauroides grandis, Ornithomimoides mobilis* and *O*.(?) *barasimlensis*.

Of the aforementioned forms *Antarctosaurus septentrionalis* has been given a new generic name *Jainosaurus* by Hunt et al. (1994) because of its distinctness from the Argentinian form, the genotypic *A. wichmannianus*. The main differences are in braincase of the Indian and Argentinian forms. Earlier Indian braincase studies on '*Antarctosaurus*' *septentrionalis* were by Berman & Jain (1982) however the specimens were recovered from Dongargaon near Pisdura. Further, *Indosaurus* and *Indosuchus* regarded by Chatterjee (1978) as a megalosaur and tyrannosaurid (respectively), are now considered as abelisaurids (see Chatterjee, this volume).

As compared to the saurischian fauna, the information and taxonomic assignment of ornithischians have remained largely in doubt.

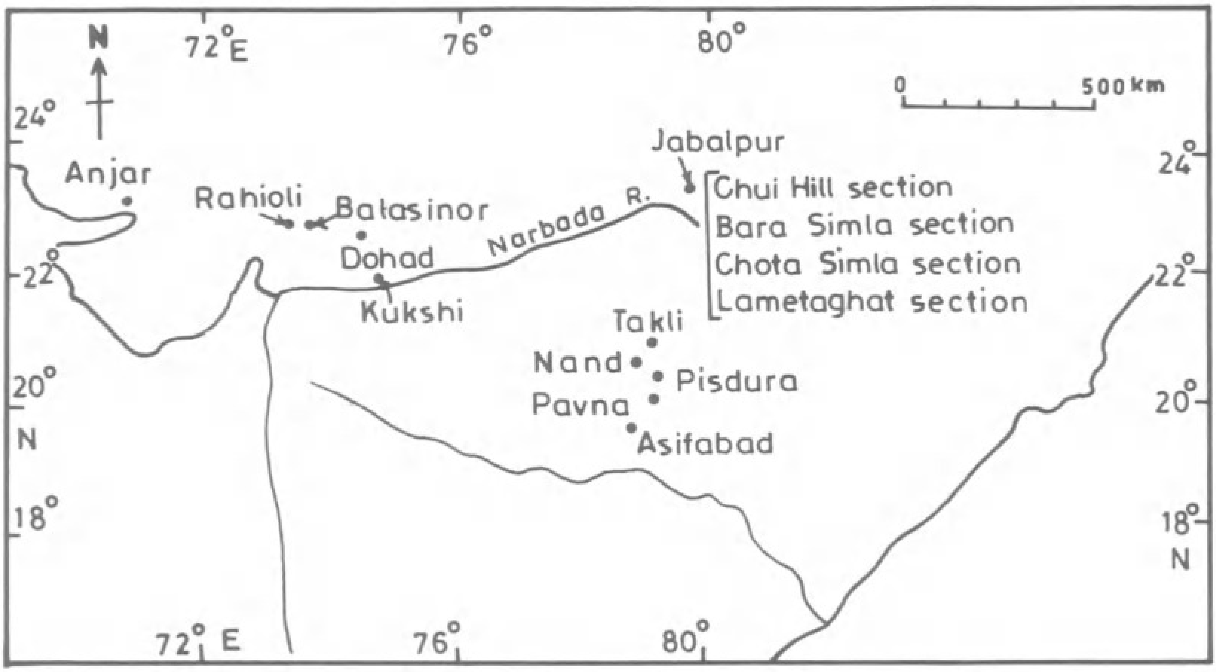

FIG. 2. Localities of dinosaur eggshells and nests in India.

Lametasaurus indicus described from Bara Simla Hill by Matley (1933) was at that time considered to be a stegosaurian. Later Chakarvarti (1934) and Walker (1964) opined that this genus could not be an ankylosaurian. Recently, works by Berman & Jain (1982), Buffetaut (1987) and Molnar & Frey (1987) opined that *Lametasaurus* could well have been a titanosaurid. Molnar (pers. comm., 1996) believes it to be a chimaera (based on bones and skeletons of saurischians and crocodilians). However a new ankylosaurian specimen is reported by Chattergee & Rudra (this volume).

From South India, the dinosaur studies were first conducted by Blanford (1862), who reported bones and a tooth of *Megalosaurus* from the same horizon in the Kallamedu Bone Bed (Ariyalur Formation, Late Cretaceous). Matley (1929) reported fragmentary bones of *Titanosaurus* along with teeth of a megalosaur and bones of a stegosaurian. Much later, Yadagiri & Ayyasami (1979) described cranial and postcranial skeleton of stegosaur *Dravidosaurus blanfordi* from the Trichinopoly Group (Turonian-Santonian). In this work, a brief mention is also made of the presence of bones of a sauropod, theropod and stegosaur from the Kallamedu Bone Bed.

EGGSHELLS. The Late Cretaceous eggshell material and nesting sites have been most abundant and have assumed considerable significance over the last decade, providing evidence of a large dinosaur hatchery (Figs 2, 3). The eggshells and nesting sites underlie the Deccan Trap flows and are uniformly found in a hard sandy carbonate with strong development of a calcretised palaeosol towards the top (Tandon et al., 1990; Jolly et al., 1990; Sahni et al., 1994, Fig. 3). In addition, Late Cretaceous eggshells are also known from the sandy limestones of the Kallankurichi Formation of the Ariyalur sequence (Kohring et al., 1996).

Up to now, considerable work has been done to categorise main eggshell morphotypes (discussed later) based on megascopic and microscopic characters (Mohabey, 1982; 1984; Srivastava et al., 1986; Vianey-Liaud et al., 1987; Jain 1989; Sahni, 1989; Mohabey & Mathur, 1989; Jolly et al., 1990; Sahni, 1993; Sahni et al., 1994 and many others). This research and the present work, have established five eggshell morphotypes, three of which have been assigned to titanosaurid sauropods (parataxonomic oofamily Megaloolithidae, Zhao, 1979) and the fourth to the ornithoid type. In a recent work, Khosla & Sahni (1995) established eight oospecies including seven of the oogenus *Megaloolithus* referable to sauropods and one, *Subtiliolithus*, an ornithoid. These oospecies are:

Megaloolithus cylindricus Khosla & Sahni (1995)(Pl. 1, Fig. A): spherical eggs 12-20cm in diameter; eggshell thickess varying from 1.7-

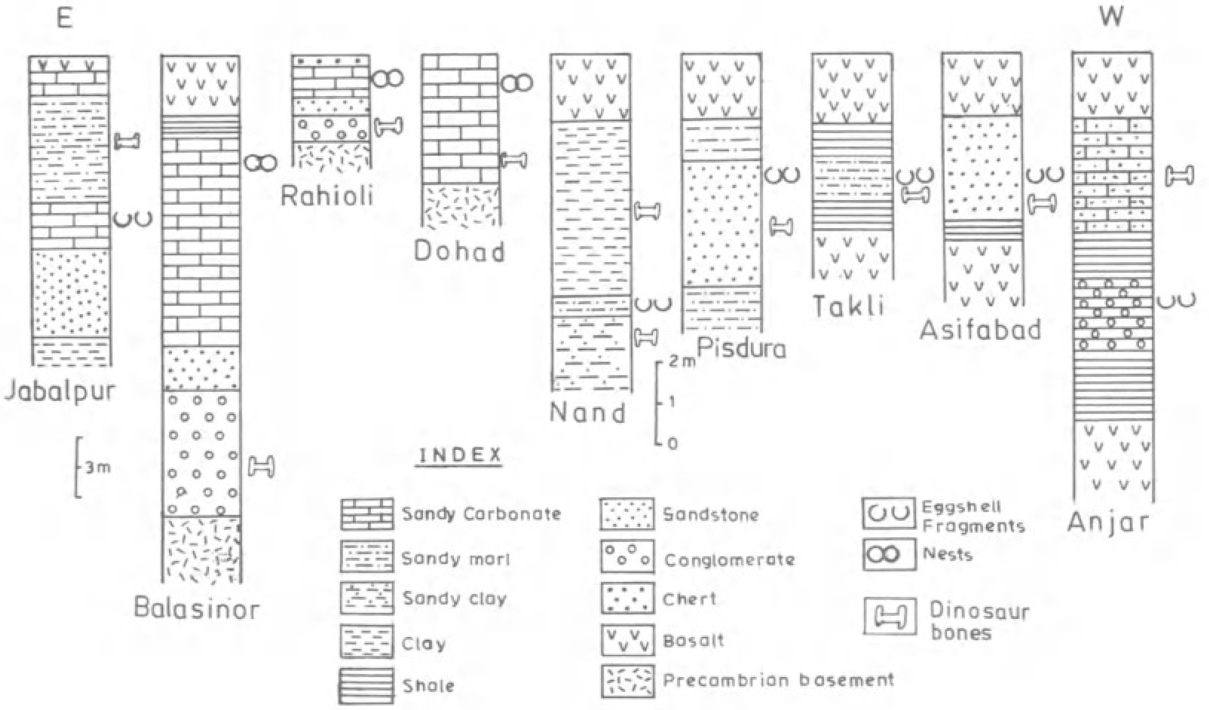

FIG. 3. Stratigraphic sections with associated eggshells and nests.

3.5mm; spheroliths cylindrical; pores subcircular; pore canals long and narrow; tightly packed subcircular basal caps, 0.2-0.5mm in diameter.

Megaloolithus jabalpurensis Khosla & Sahni (1995)(Pl. 1, Figs B, C): spherical eggs 14-16cm in diameter; eggshell thickness 1-2.3mm; nodose external surface; spheroliths with varying width and shapes; elongate to circular pores; tightly packed basal caps (more so than in *M. cylindricus*) 0.1-0.5mm in diameter.

Megaloolithus mohabeyi Khosla & Sahni (1995): spherical eggs 16-19cm in diameter; eggshell thickness 1.8-1.9mm; nodose external surface; spheroliths long and fused to adjacent ones; growth lines convex to undulating; pores elliptical; broad and semicircular basal caps, 0.14-0.21mm in diameter.

Megaloolithus baghensis Khosla & Sahni (1995)(Pl. 1, Fig. D): spherical eggs 14-20cm in diameter; eggshell thickness 1.0-1.7mm; nodes discrete to fused; spheroliths fan-shaped, distinct or partially fused and look more compressed when ending in multiple nodes; pores subcircular to elliptical; basal caps swollen-ended, 0.2-0.3mm in diameter.

Megaloolithus dholiyaensis Khosla & Sahni (1995): eggshell thickness 1.47-1.75mm; nodose outer surface; spheroliths cylindrical and fan-shaped; pore canals straight; basal caps subcircular to conical, isolated to fused, 0.15-0.30mm in diameter. So far found only as fragments.

Megaloolithus walpurensis Khosla & Sahni (1995): eggshell 3.5-3.6mm thick; spheroliths irregularly fan-shaped and showing fusion towards the outer surface; pore canals short, thin, slender, with slit-like openings; basal caps conical to subcircular, 0.25-0.30mm in diameter. So far found only as fragments.

Megaloolithus padiyalensis Khosla & Sahni (1995): eggshells 1.12-1.68mm thick; nodose external surface; small irregular, slender spheroliths; small and large pore canals; basal caps circular to semicircular, 0.07-0.21mm in diameter. So far found only as fragments.

Subtiliolithus kachchhensis Khosla & Sahni (1995)(Pl. 1, Fig. E): eggshells extremely thin, 0.35-0.45mm; external surface exhibits irregularly spaced microtubercles; double layered; spongy layer poorly defined; mammillary layer 1/2-1/3 of the total eggshell thickness; mammillae tightly packed, 0.03-0.05mm in diameter. So far found only as fragments.

The eggshells referred to a new morphotype (Elongatoolithidae) were recovered from near Rahioli (district Kheda, Gujarat) and work on them is in progress. This morphotype is currently being described in detail with Dr D.M. Mohabey, GSI, who has also recovered the same type of

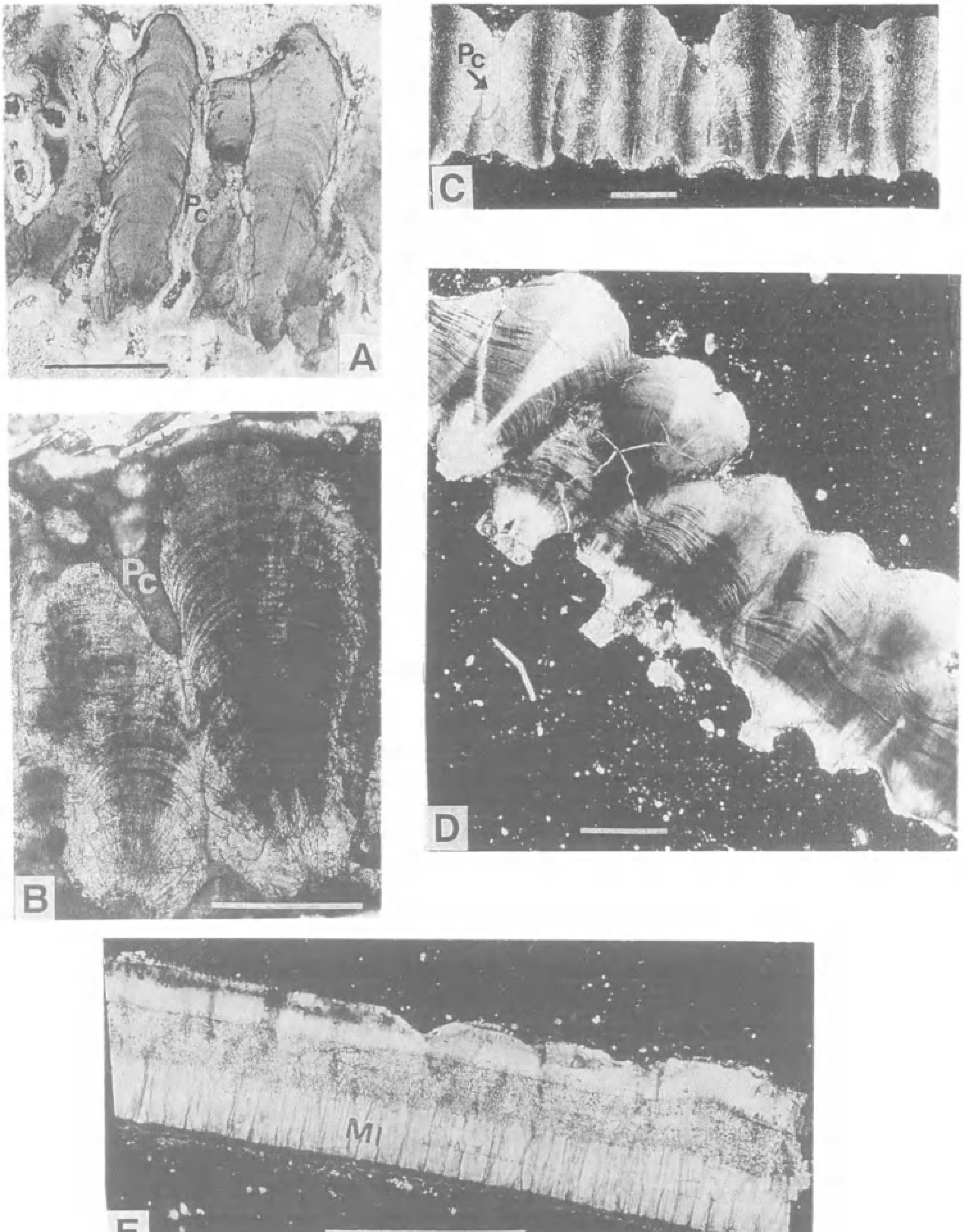

PLATE 1. A, Radial view of *Megaloolithus cylindricus* (VPL/AK 220), Pat Baba Mandir, Jabalpur (Madhya Pradesh). Note cylindrically shaped spheroliths. B, Radial view of *Megaloolithus jabapurensis* (VPL/AK 275), Bara Simla Hill, Jabalpur (Madhya Pradesh), showing small and large fan-shaped spheroliths. C, Radial view of *Megaloolithus jabalpurensis* (VPL/AK 276), Bara Simla Hill, Jabalpur (Madhya Pradesh). Note sweeping extinction pattern of spheroliths. D, Radial view of *Megaloolithus baghensis* (VPL/AK 556), Pisdura, Chandrapur district, Maharashtra. Note small and large fused spheroliths with moderately arched growth lines. E, Radial view of *Subtiliolithus kachchhensis* (VPL/AK 580), Anjar, District Kachchh, Gujarat. Note two-layered eggshell. Mammillary layer is well defined while spongy layer is faintly developed. ML=mammillary layer, Pc=pore canal; scale = 500μm. (VPL/AK=Vertebrate Palaeontology Lab./Ashu Khosla).

eggs. These eggshells are ellipsoid in shape, with a thickness of 1.2-1.6mm, and ornamentation varying from sagenotuberculate (at poles) to lineartuberculate in the equatorial region. The microstructure shows a double layer with radiating structures in the mammillary zone —the latter being about half of the total thickness. Gently curving growth striations are observed in the outer spongy layer. The spheroliths are slender and fused towards the upper part.

TRACKS. As well as the skeletal and eggshell material, dinosaur pedal tracks are also known from the Early Cretaceous Bhuj Formation exposed in the Pakhera and Fatehgarh areas of Kachchh (Ghevariya & Srikarni, 1990). From the Pakhera area, tracks belonging to a juvenile and an adult individual were reported. These types were interpreted as ornithopod, as claws were absent. From the Fatehgarh area, diversely shaped (rectangular, oval and diamond shaped) tracks were described from hard sandstone; the associated grey shale bears an Upper Gondwanan plant, *Ptilophyllum*.

PALAEOENVIRONMENTS

The Triassic Maleri Formation, has long been thought to have been deposited in a river valley system, the sandstones representing the channel deposits and clays suggesting an interchannel floodplain (Jain, 1990). The cross-bedded and lenticular sandstones represent cut-off meanders of the mainstream, with clays deposited on waterlogged floodplains (Sengupta, 1970). Jain (1990) described the general environment of the Maleris as indicative of well-aerated country, inhabited by aquatic vertebrates, in a forest habitat. The waterholes and their environs were dominated by amphibians and arboreal vertebrates. The eosuchian *Malerisaurus* probably lived on floodplains or marshy land close to lakes.

The environment for the overlying Dharmaram Formation, from its base to the top of the lower Kota Formation is similar to that of an upwardly-fining sequence deposited under a laterally shifting meandering stream (Rudra, 1982).

As mentioned earlier, the overlying Kota Formation is a typical continental deposit. There were two kinds of depositional environment: sandstones and clays representing fluviatile conditions (river deltas), and thin limestones suggesting deposition in inland lakes (Robinson, 1970). Further, two different climatic conditions also prevailed; one with moderately high relief and rainfall and the other low relief and rainfall. Tasch et al. (1975), on the basis of conchostracans, and Govindan (1975), on the presence of ostracodes, supported a fresh water environment for the deposition of the limestone within small basinal ponds. According to Rudra (1982) the Kota Limestone suggests periodic precipitation of impure lime muds in freshwater playa-type lakes. The presence of inclined and vertical burrows indicates quiet sedimentary episodes, and pelletoid-bearing laminations indicate a very slow rate of sedimentation (Maulik & Rudra, 1986). Periods of drought are also suggested by the presence of semionotid fish in cracked limestone — this circumstance has been explained by Jain (1980; 1983) as owing to the mortality of semionotids in the oxygen-deficient evaporating water of the Kota lakes. The large sauropods, such as *Barapasaurus*, inhabited land close to the Kota lake and fed upon the aquatic vegetation, while the crocodiles fed on fishes and lived on the banks (Jain & Roychowdhury, 1987). Broadly, the Kota lake environment is pictured as a shallow water body, with pholidophorids and coelacanths inhabiting its deeper parts.

The Late Cretaceous Lameta Formation has provided a fairly extensive record of terrestrial dinosaurs, ostracodes, charophytes and invertebrates; the environmental interpretation has therefore been of much fascination.

The marine interpretation of the Lameta Formation is based on the presence of algal-like structures, glauconite beds and thalassinoid burrows (Chanda, 1963; Chanda & Bhattacharya, 1966). Singh (1981) opined that both the Bagh and Lameta Formations are the product of a Turonian-Senonian marine transgression; wherein an estuarine tidal flat complex was indicated by crab burrows, bioturbated carbonate and marl facies.

The marine interpretation was first challenged by Brookfield & Sahni (1987) who believed that the evidence favouring a marine environment may have been misinterpreted, for instance the algal structures in the limestones are pedogenic carbonate structures of palaeosols. Further, on the basis of the dinosaur eggs, bones and associated freshwater biota (charophytes, ostracodes and other invertebrates), it was concluded that the entire Lameta sequence consists of pedogenically-modified piedmont calcrete deposited in a semi-arid environment dominated by a large river.

Subsequently, on the basis of Matley's (1921) map of the Jabalpur area, Tandon et al. (1990) studied the sedimentology and facies of sections

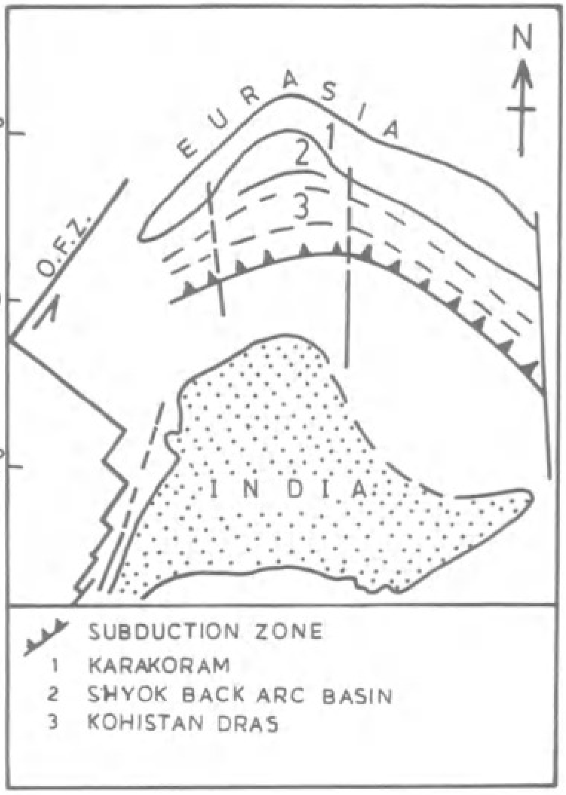

FIG. 4. Late Cretaceous palaeoposition of the Indian plate and Kohistan-Dras Island Arc (after Sharma, 1987; Sahni & Bajpai, 1991).

at Lametaghat, Chui Hill and Bara Simla Hill in detail. At Bara Simla Hill they identified several undulations associated with 'relief highs' and 'relief lows' — these were interpreted (through computer studies) to represent shoulders and ramps on an ancient geomorphic surface. The relief high characterises dinosaur nest-bearing nodular carbonates, while the relief lows are associated with a marly dinosaur bone-bearing horizon. Both these palaeo-relief surfaces form part of fanpalustrine flat system with repeated sheetwash activity, wherein the upper sandy carbonate represents emergent areas with high pedogenic modification, while the lower marly facies has low pedogenic modification (Tandon et al., 1990; Sahni et al., 1994).

Further, the nesting sites, in as much as they are associated with pedogenic calcrete, fringed small lakes. Desiccation and subsequent sheetwash activity occurred leading to rapid matrix cementation and preservation of large dinosaur nests (Jolly et al., 1990). In this context extensive field work at Bara Simla Hill, Chui Hill and Lametaghat suggest a single stratigraphic level of sauropod nests associated with pedogenic calcretes in the Lower Limestone layer (Sahni & Khosla, 1994). Evidence of multiple layers of nesting is absent; the different topographic levels can be explained by the undulatory character of the palaeogeomorphic surface (Tandon et al., 1990). As such there is a strong evidence for 'site selectivity' on the part of the dinosaurs, rather than site fidelity. Moreover, the pedomorphic surface along the entire stretch of terrain from Jabalpur in the east towards Gujarat in west was selected by the sauropods for nesting sites (Jolly et al., 1990).

An alluvial-limnic environment under semi-arid conditions was suggested for various subenvironments of the Lametas exposed in Dongargaon Hill and Dhamni-Pavna sections by Mohabey et al. (1993). The eggshell-bearing horizons, especially near Pavna, are associated with overbank facies. Pink and red clays suggest the leaching action of reducing waters with occasional ponding of water, as shown by freshwater charophytes and ostracodes. However, at Pisdura and Dongargaon, a channel facies with immature pebbly and gritty sandstones with calcrete layers was delineated, with cross-stratification, convoluted bedding and channel fill structures. The lacustrine facies is characterised by finely laminated silty clays and contains *Lepisosteus, Lepidotes* and ostracodes (*Candionella* and *Mongolianella*).

The palaeophysiologic conditions of the Indian Cretaceous eggshells have been characterised mainly on shell thickness, pore distribution, density, pathologic thickening or thinning and resorption of mammillae (Sahni et al., 1994). The porosity values, which reflect nest humidity, for the eggshells are substantially less; these values are measured by water vapour conductance which vary from 2.65mg/(day.tor) to 3.49mg/(day.tor); such low values are probably due to the semi-arid environment.

The O^{18} and C^{13} values of the Lameta eggshells indicate that dinosaurs drank water from rivers and evaporating pools and consumed C-3 type plants, such as palms, dicot shrubs and conifers (Sarker et al., 1991).

PALAEOBIOGEOGRAPHY

Until recently, the main arguments supporting the hypothesis of Gondwanaland were derived from glaciation and distinctive floras. In recent years geophysics and oceanography have contributed suggestive new data, but it is the information from Gondwanan vertebrates that has proved to be of inestimable value in providing a clearer palaeobiogeographic analysis in the scenario of drifting plates.

A look into the affinities of the Indian Gondwana tetrapods clearly provides sufficient evidence of Laurasian influence in these palaeocommunities, with no endemism. The Triassic Maleri dinosaur *Alwalkeria* is more or less similar to *Coelophysis* of North America and *Procompsognathus* of Germany. The lower Jurassic Kota dinosaur, *Barapasaurus tagorei* bears affinities to the European *Ohmdenosaurus liasicus*, Patagonian *Patagosaurus fariasi* and Chinese *Shunosaurus lii*.

Significant evidence, however, is the discovery of Maastrichtian mammal *Deccanolestes hislopi* in the Intertrappeans of Naskal, Andhra Pradesh (Prasad & Sahni, 1988). This genus shows morphological similarity to the North American *Cimolestes* and Mongolian *Kennalestes*.

Palaeorycted mammals are also known from the Paleocene of Morocco (Cappetta et al., 1978). In addition to palaeoryctids, molar teeth belonging to Docodontidae are known from the Late Jurassic of India (Prasad & Khajuria, 1990). Besides, pelobatid frogs, lizards and turtles, known from the Intertrappean beds of Nagpur, are also known from North American and Russian localities.

Amongst the invertebrates, the Intertrappean of Nagpur has yielded *Cypris, Candona, Altanicypris*, which are similar to Mongolian-Chinese form. Charophytes, such as *Platychara perlata* known from the Intertrappeans, are closely similar to *P. compressa* of North America. The aforementioned picture of lack of endemism and the cosmopolitan distribution of Indian dinosaurs, has been utilised and interpreted by some stabilists, who have invoked static models of Indian-Eurasian plates and their contiguity in the past (Chatterjee, 1984; 1987; Chatterjee & Hotton, 1986). These workers are of the view that India was never an island continent during its convergence towards Eurasia, and believed in a narrower Tethys with India occupying a position between Somalia and Eurasia in its pre-drift position (Chatterjee & Hotton, 1986). Also, the presence of Laurasian biotas in India and migrations, may be a consequence of land corridors between India and Eurasia that were maintained during Cretaceous (Chatterjee, 1992).

However the work of ardent mobilists, notably Sahni (1984), Sahni & Bajpai (1991) and Loyal (1984, 1985), have seriously questioned the validity of Chatterjee's (1984, 1987) conclusions. Sahni (1984), while analyzing and admitting the Eurasiatic faunal presence in the Indian Gondwanas, concluded that migration of land faunas took place during the Cretaceous-Palaeocene from the eastern part of Africa, as India was then close to Madagascar. Later, Sahni et al. (1987) and Sahni & Bajpai (1991) suggested that the necessary land passage might have been provided by the island arcs of Dras Volcanics (Fig. 4); this activity might have been initiated earlier, in Late Jurassic (Sharma, 1987). In this context, an early Cretaceous India-Eurasia collision was suggested by Jaeger et al. (1989).

Further, to account for the cosmopolitan distribution, one of us (RSL) is of the opinion that two dispersal corridor routes existed for Gondwanaland-Laurasia intermigrations, viz. India-South Tibet-Afghanistan-Iran-Turkey and India-Africa-Siberia (Loyal, 1985). The fragmented portion of northernmost Gondwanaland (Tibet, Iran, Iraq, Afghanistan) formed a migrating festoon of island arcs, establishing links with Eurasia throughout Late Permian-Cretaceous. Therefore, these paths of migration (in Laurasia and Gondwanaland) were extremely significant in as much as they help explain the lack of faunal endemism of the Indian biotas during its time of geographic isolation and rapid northward journey.

Finally, though there exists now (as aforementioned) a growing body of vertebrate and invertebrate faunal data from the Indian Plate, pointing to strong India-Laurasia links similar palaeobiogeographic data from other Gondwanic areas (Africa, S. America, Antarctica, Australia) is almost meagre. Therefore, in this context, Laurasia-Gondwanaland faunal comparisons remain poorly understood: hence urgent and extensive fieldwork in the Mesozoic terrain of Gondwanic regions is necessary.

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