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SEM STUDIES OF THIN EGG SHELL FRAGMENTS FROM THE INTER-TRAPPEANS (CRETACEOUS-TERTIARY TRANSITION) OF NAGPUR AND ASIFABAD, PENINSULAR INDIA.

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ABSTRACT

Fossil egg shell fragments of extreme thinness, 120-400 microns are reported from the Intertrappean localities of Nagpur Asifabad in peninsular India. These finds are in addition to fossil egg shell findings already reported from Gujarat and Jabalpur. The thin egg shell fragments have been studied by scanning electron microscopy and exhibit a tuberculate or nodular external surface, poorly developed to well developed spherolithic texture and an extremely well developed mammillary surface. The affinities of thin egg shells are somewhat uncertain to establish. Morphologically, the Asifabad egg shells are close to those of sauropod dinosaurs. The Nagpur egg shell may have an avian or lacertilian affinity. The egg shell fragments are associated with a rich assemblage of microvertebrates including some dinosaur elements, charophytes, ostracodes and molluscs of Upper Cretaceous-Palaeocene age.

INTRODUCTION

During the last two years considerable progress has been made in the location of new fossil egg shell localities in India and the study of fossil egg shell fragments by means of scanning electron microscopy. Concerted efforts have resulted in the discovery of two additional localities in peninsular India, namely Nagpur and Asifabad. The earliest report of a fossil egg from India was documented by Sahni (1957) from the Uttattur Formation (Cenomanian) of South India. The isolated but complete egg has a length of 49 mm and width of 27 mm and is considered to have affinities with marine turtles. It was found associated with marine invertebrates. The next report of egg shell fragments referable to dinosaurs was that by Sahni and Gupta (1982) from the Lower Limestone horizon of Lameta Formation, Jabalpur. The ultrastructural characteristic of these egg shells is different from those discovered by the G. S. I. from the Rahioli-Balasinor area, Khaira district, Gujarat (Srivastava, 1982; Mohabey, 1984). The Gujarat egg shell finds are being studied jointly by the G. S. I. and one of us (A. S.). Another locality from which egg shell fragments of avian affinity are reported is the Pleistocene Karewa locality of Jammu and Kashmir (Sahni *et al.* in press).

The present paper deals with very thin egg shells found during the screening and washing processes of microvertebrate recovery from two localities in peninsular India viz., Nagpur and Asifabad (Fig. 1). About 40 to 50 egg shell fragments were recovered by screening over 3 tonnes of material from the Takli Formation of Nagpur during the years 1981-84. Similarly, more than 75 egg shell fragments have been recovered from coeval beds of Asifabad region, A. P.

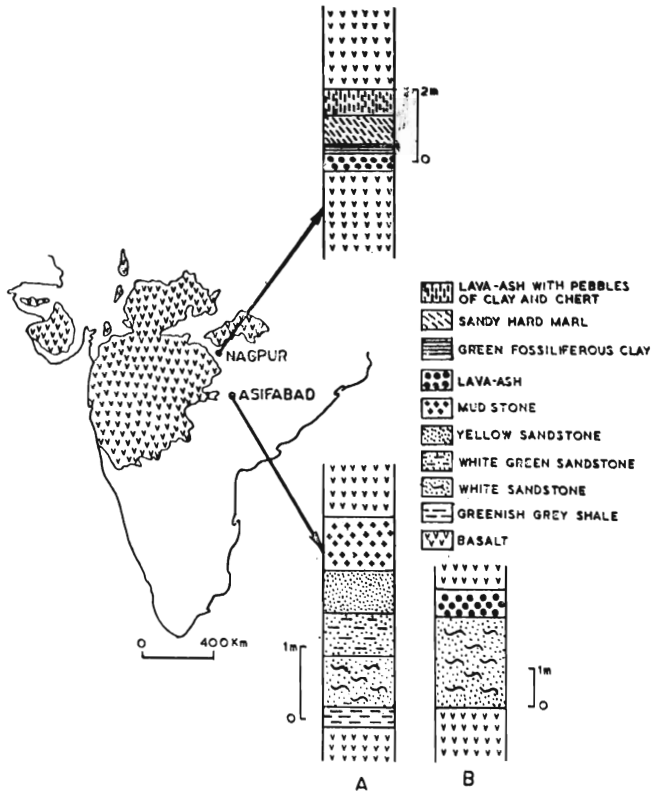

Fig. 1. Location and stratigraphic section of egg shell localities of Nagpur and Asifabad.

during the years 1982-84 by screening over one ton of rock material. The recovery percentage is not very high. The fragments are characteristically associated with fluvio-lacustrine and coastal plain biotic assemblages occurring between the initial basaltic lava Flow 1 and the immediately overlying basaltic Flow 2. Associated microfossils include diverse microvertebrates, ostracodes, gastropods, pelecypods, marine algae, charophytes and some seeds.

The age of these horizons has been discussed at length by Wensink *et al.* (1979), Sahni *et al.* (1982), Sahni (1983) and Rana (1984). The evidence furnished by the microvertebrates and associated microfossils of both Nagpur and Asifabad intertrappeans is suggestive of Late Cretaceous-Early Palaeocene age. Further precision in determining the age of these beds is not possible at present as the radiometric data tends to give younger ages for stratigraphically older rocks (Alexander, 1981). The palaeomagnetic data is as yet meagre. The presence of dinosaurs in the Nagpur and Asifabad intertrappeans which are traditionally believed to be Palaeocene age on the basis of mega plants and microfloral evidence (Sahni, 1934; Prakash, 1960) complicates the matter further. The characteristic plants of Early Tertiary aspect are the palms *Nipa* and *Rodeites* (Prakash, 1960) and two species of the hydroptid, *Azolla* (Sahni, 1934).

NAGPUR

The Nagpur egg shell locality is situated about 4 km northwest of Nagpur railway station. The section attains a thickness of about 20 m. A massive basalt (Flow 1) underlies the Takli Formation. The Takli Formation is 2.25 m in thickness (Text fig. 1). The base of the Takli Formation consists of a lava ash bed which is overlain by a compact, fine-grained, green fossiliferous clay bed yielding abundant microvertebrates and other microfossils. The green clay bed is in turn overlain by compact, coarse grained, richly fossiliferous sandy hard marl. The egg shell fragments are found both in the green clay and sandy marl beds. The uppermost bed of the Takli Formation is a sedimentary lava ash bed and is covered by Deccan basalt (Flow 2).

FOSSIL CONTENT

Takli Formation is rich in both vertebrate and invertebrate fossils. The invertebrates are represented by molluscs and ostracodes. The molluscan fauna comprises *Paludina*, *Valvata*, *Limnaea* and *Physa*. Ostracodes are also abundant comprising *Paracypretta*, *Mongolianella*, *Cyprois*, *Condoniella* and *Metacypris* (Bhatia and Rana, 1983). The vertebrates are represented by *Dasyatis*, *Lepidotes*, *Lepisosteus*, *Pycnodus*, *Enchodus*, *Phyllodus*, *Belonostomus*, *Phareodus*, *Arius*, *Epinephelus*, *Kuhlia*, *Gobius*, *Sphyraena*, *Stephanodus*, pelobatid frogs, turtles, scincomorph (Anguidae) lizards, boidae snakes, *Crocodylus*, carnosaurian teeth and possibly symmetrodont mammals (Rana, 1984). Charophytes are also common and are represented by *Platychara* and *Microchara*, etc.

AGE OF TAKLI FORMATION

There are many controversies regarding the age of Deccan Intertrappean beds. On the basis of floral remains, the age of Deccan intertrappean beds is considered to be Palaeocene (Bande *et al.*, 1981). On the basis of charophytic assemblages, Bhatia and Mannikeri (1976) suggest an age ranging from Montian to Landenian for the Nagpur Intertrappeans. Sahni *et al.*, (1982), on the basis of microvertebrate assemblages assigned an Uppermost Cretaceous to Palaeocene age to the Takli Formation. The presence of typical Cretaceous elements such as dinosaurs and a symmetrodont mammal, however, create some uncertainity regarding the younger age limit of Takli Formation. It is possible that the intertrappeans may extend down to the Uppermost Cretaceous age if dinosaurs are accepted to be restricted to the Cretaceous. However, there are some isolated findings of Palaeocene dinosaurs (Erben *et al.*, 1983) and an earlier prediction of finding Palaeocene dinosaurs in India (Van Valen and Sloan, 1977).

The strongest evidence for the age of Takli Formation comes from radiometric and palaeomagnetic studies by Wensink *et al.*, (1979). These studies indicate that Takli Formation is older than the age for the upper trap in Nagpur region i.e. 57.3 ± 2.9 m.y. and lies somewhere between anomaly 26 and 31. Magnetic polarity studies by Wensink *et al.* (1979) indicate a zone of polarity reversal at Nagpur corresponding to the minimum age at the Lower Palaeocene.

ASIFABAD

The two stratigraphic sections (A and B) from which the egg shell fragments are recovered, are situated 2 km. south and 4 km southwest of the village Ada, near Asifabad. The base of the section A located 2 km south of the village Ada is partially exposed, and at a lower level, loose weathered basalt can be seen. The basal rock is a greenish grey shale with a thickness of 0.25 m above the ground surface. This bed is embedded with limestone nodules and numerous poorly preserved shells of molluscs. Above the greenish-grey shale is the calcareous gritty, white sandstone which attains a thickness of

0.75 m. This horizon has yielded charophytes, ostracodes, gastropods and other microvertebrates. The white sandstone grades vertically into whitish-green sandstone with an increase of clay content. The whitish-green sandstone measures upto 0.60 m and the fossils found are essentially ostracodes and pelecypods. About 20 thin egg shell fragments and five thick egg shell fragments were recovered from both the white and whitish-green sandstone. The whitish-green sandstone is overlain by soft, finegrained, pale yellow sandstone of 0.60 m thickness. This horizon yields mainly microvertebrates represented by dasyatids, myliobatids, *Rhinoptera*, *Rhombodus*, pycnodonts, *Stephanodus*, *Enchodus*, *Belonostomus*, *Lepisosteus*, *Phareodus*, pelobatid frogs, turtles etc. A mudstone bed of 0.75 m thickness overlies the yellow sandstone and yields similar fossils as that of the underlying bed. The top of the section is occupied by loose soil of 1m thickness. As one moves along this hill section, at an higher level, massive, weathered basalt without any bedding can be seen. Spheroidal weathering is a common feature of the basalt.

Section B exposed near the village Kotari 5 km south-west of Ada is underlain by massive weathered basalt whose base is unexposed. Overlying the basalt is a calcareous, gritty, white sandstone similar to that of the Ada section. This bed measures upto 5 m vertically and is unfossiliferous whereas the one overlying the white sandstone resembles the yellow sandstone horizon of the Ada section. This horizon is 1.5 m thick and yields thin egg shell fragments along with marine microvertebrates such as dasyatids, pycnodonts, *Stephanodus*, etc. The frequency of freshwater forms is not high and these are represented by a few maxillae of frogs, charophytes and ostracodes. A few foraminifers are also found in this horizon. The top of the section is covered by 2 m thick soil. As in the case of the Ada section, here also the Deccan basalt is seen exposed at an higher level.

As far as the age is concerned, Asifabad intertrappeans are poorly studied formations, the only report being that of Rao and Yadagiri (1981). They proposed a Cretaceous age for these formations based on the dinosaurian remains. Subsequent investigations also proved the presence of dinosaur remains in the Asifabad intertrappeans (G.V.R. Prasad, work in progress). As in the case of Takli Formation, the microvertebrates and the associated microfossils of Asifabad Intertrappeans favour a Late Cretaceous—Early Palaeocene age.

DESCRIPTION

The remains of thin fossil egg shell fragments are found associated with microvertebrates in all the localities that were investigated. About 90% of the egg shell remains are extremely thin ranging from about 120 μm to 180 μm while a few fragments are slightly thicker, ranging from 300 μm to 400 μm. All the egg shells are well below the average thickness of known dinosaur fossil egg shell fragments of America (Jepsen, 1931 ; Jensen, 1966 ; Sahni, 1972 ; Hirsch, 1979, 1983 and Horner, 1982), France (Dughi and Sirugue, 1957, 1958, 1959, 1962, 1966 1976), Mongolia (Van Straelen, 1928 ; Sochava, 1969, 1970, 1971) and China (Chow, 1951, 1954 ; Young, 1959, 1965, 1979 ; Chow and Chiung, 1974 ; Zeng and Zhang, 1979 and Zho, 1979). Thin dinosaur egg shells have been reported by Erben (1970) from Aix en Provence locality in France, but their thinness has been attributed to physiological and pathological causes (hormonal disbalance). In the French locality, the percentage of thin to thick egg shell is small in the basal part of the section but becomes, towards the top, comparable to the ratio found in the Nagpur and Asifabad localities. This condition in the intertrappeans may indicate that the thinness of the egg shells is either a pathological condition, or that it is the normal structure of a presently unidentified taxa. Further similarities with the French localities can be noted :—In both the Indian and French localities, the egg shells are associated with the remains of dinosaurs (mainly titanosaurid sauropods ; Fig. 2A).

At Nagpur, the presence of dinosaurs was inferred on the basis of an isolated theropod tooth related to *Massospondylus* (*M. rawesi*) by Lydekker (1890) and several other serrated tooth fragments found by Indo-French team of research scientists (Sahni *et al.*, 1982). At Asifabad, the presence of dinosaurs in the intertrappeans was first reported by Rao and Yadagiri (1981). They reported a few limb bones probably having affinities to those of the sauropods. Recent studies in the same area confirms the presence of dinosaurs in the intertrappeans. Apart from dinosaurs, the remains of other reptiles to which the eggs may be attributed to, are found at Takli, Nagpur. These reptiles include lizards, crocodiles, snakes and trutles. Most of these reptiles, do not have many documented reports of egg shells in the fossil records. Turtles are one exception to this rule as some turtles are known to have a well calcified shell structure unlike those of fossil lizards, snakes, and crocodiles. Fossil turtle egg shells have been reported from India (Sahni, 1957) and their occurrences have been recently reviewed (Hirsch, 1983). Fig. 1 shows the variation in ultrastructure in the egg shells of dinosaurs, birds, lizards, turtles and

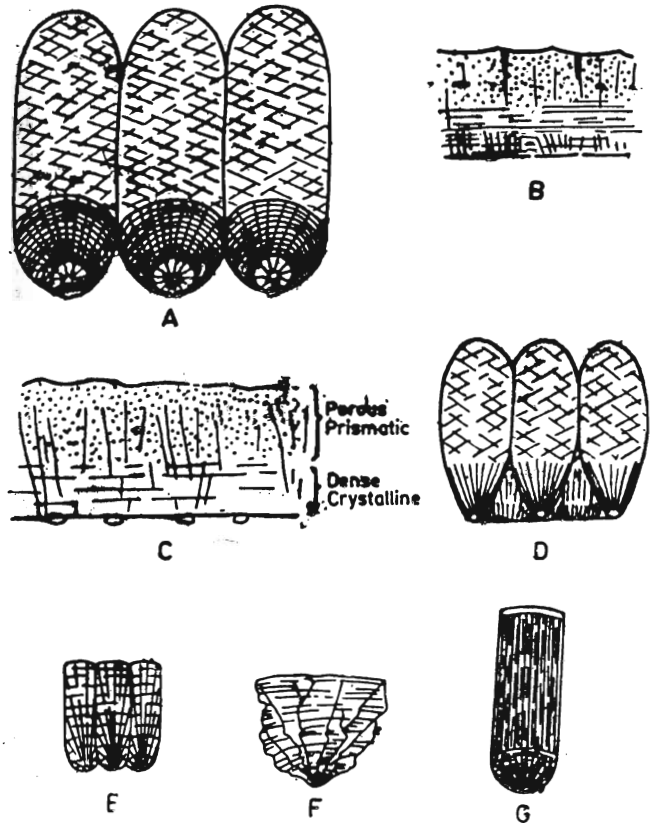

Fig. 2. Egg shell ultrastructure of a few representative vertebrates. A—Dinosaur, Aix-en provence (France); B—Dinosaur, Jabalpur (M.P.); C—Avian or laceitilian, Nagpur; D—? Sauropod, Asifabad; E—Recent chelonian; F—Recent crocodiles; G—Recent Avian.

crocodiles. Though observable morphological differences can be discerned between the above type of egg shells, a small amount of uncertainity remains as to the association of the egg shells with their parent animals as most of the material is found by screening and washing techniques, by which it is impossible to relate the egg shell to a particular faunal component member. The recognition of the association of dinosaur egg shell is easier as egg shells are found in clutches sometimes associated by skeletal material (Erben, 1970 ; Srivastava, 1982 ; Horner, 1983 ; Mohabey, 1984) and even embryonic skeletons Sochava, 1970). However, even amongst the di-, nosauria, the identification of the sauropod egg shells from those of supposed theropod or hadrosaur affinities is beset with difficulty. As may be expected, nesting sites were exclusively reserved areas for a particular population of a species and hence most of the complete egg shells (nests) probably belong to a single species. However, in deposits where egg shells have accumulated by transport, the identification of the egg shells is based by inference on the frequency of occurrence of egg shells to known faunal members or to morphological comparison to egg shells of proven identity (from other localities).

Except for one locality in India (Rahioli) where complete nests are preserved, the other occurrences represent isolated finds (Jabalpur-Sahni and Gupta, 1982), and the presently described forms from Nagpur and Asifabad. In most spherical (sauropod type) egg shells the ornamentation is fairly constant over the entire surface area, in egg shells which are oval and elongated (as the vast majority of the Chinese and Mongolian ones are: Chow, 1951; 1954; Young, 1959, 1965; Van Straelen, 1928; Sochava, 1969, 1970, 1975) there may be some variation in the external sculpturing depending upon the area of the egg shell fragment involved. Egg shells of variable sculpturing can be found at Jabalpur and the presently described localities (Fig. 2B).

The external sculpturing is fairly characteristic. This may consist (in sauropods) of discrete tubercles or nodes which may coalesce to form hummocky ridges. In most instances, each sauropod tubercle gives an indication of a complete unit, the spherolith. In other egg shells studied from the Judith River Formation of Montana (Sahni, 1972) a variety of external sculpturing is found. The position of pores is also related to the type of external sculpturing. Sometimes the pores are found in the hollows of ridges, they may occur in pairs (Montana and China). Not all dinosaur egg shells have an ornamented external surface, some of these may be smooth as in AMNH-8544-AMNH-8548 (from Judith River Formation of Montana, Sahni, 1972; Fig. P to X). In lizards, crocodiles and turtles, the external surface is usually smooth. The same condition is applicable to the egg shells of modern birds where microrelief structure (visible by SEM at high magnification about 2500-4000) may be discerned, but the outer shell is itself not ornamented. The external sculpturing of ancestral avian egg shells is conjectured in view of known modest ornamentation in Oligocene birds (Hirsch, 1979). High tuberculated, ridged and pitted shells are the most common characteristic of dinosaur egg shells.

The egg shell fragments are best studied in transverse section by combined means of optical microscopy and scanning electron microscopy. Light microscopy is useful particularly when the egg shells are highly replaced or diagenetically altered. In such instances, thin section still retain part of the original cross stratification or spherolith structure. Moreover, minerally altered regions of the egg shell can be easily made out as can be the course of the pores through the thickness of the shell fragment. These features cannot be so easily discerned by SEM. However, ultrastructural studies are fundamental to the identification of egg shells as they permit high resolution photography and back scattered images in addition to

microscopic analysis helps in the identification of chemical compositional differences. The transverse sections have been dealt in great detail by Sochava (1969, 1970, 1971); Erben (1970); Dughi and Sirugue (1957, 1958, 1959, 1966, 1976).

NAGPUR EGG SHELLS

The Nagpur egg shells are found in both the lower and upper ossiferous horizons of the Takli type section at Nagpur. As noted earlier (Rana, 1984)., the lower horizon represents transported elements as is noted by the assorted and fragmentary nature of the skeletal and molluscan material. The upper horizon indicates more tranquil nature of deposition. The egg shell fragments in both horizons are however of the same size about 1-2mm². The egg shells are similar superficially to the abundant pulmonate gastropod shell fragments, but can be differentiated from them on the basis of external ornamentation and the presence of distinct and discrete mammillae on the internal surface (Fig. 2c).

The external surface is ornamented by coalescing ridges and isolated solitary tubercles (Pl. I—1). The ridge axes are subparallel to each other. All the Nagpur fragments have a similar ornamentation, though in some the percentage of isolated tubercles to coalescing ridges may be higher. In fractured transverse section (Pl. I—4; Pl. II—3) the major structural features are vertically oriented prismatic elements. The prismatic elements either extend throughout the thickness or are confined towards the internal one-third of the shell (Pl. II—3). The vertically directed layers are highly porous (Pl. I—5). In polished sections, there is a basally differentiated dense, massive crystalline layers with a tabular aggregate of crystals (Pl. I—3 and Pl. II—1, 2). Coarse, horizontal stratification occurs near the internal surface. Vertical elements are equally well developed and as in fractured specimens, are seen to extend throughout the thickness. The mammillary surface has well developed spicular mammillae of variable sizes (average diamter-5 μm to 15 μm, Pl. II—5, 6). At lower magnification, it can be seen that the mammillae occur in groups of variable numbers and are separated from each other by troughs.

ASIFABAD EGG SHELLS

The Asifabad egg shells are of two types (Pl. III—1, 2). The majority of them about 75% specimens are within the same thickness range as the Nagpur specimens, 4-5 specimens are somewhat thicker. No shell over 0.5 mm has yet been found in this locality. The Asifabad thin egg shells appear to be morphologically different to the Nagpur ones, although in the external ornamentation and mammillary structure there are no basic differences. The main difference lies in the structure seen in transverse section (Fig. 2D). In fractured transverse section, the individual spheroliths are distinct elements and similar in structure to that seen in sauropod dinosaurs. The mammillary layer is confined to the internal surface and consist of parallel calcitic ridges extending towards the mid-thickness of the shell. These columns are massive and have a distinct boundary between adjacent columns which becomes more intensified on etching. The spherolithic structure is well seen in Plate III—1 which represents a fractured surface, Plate III—3 which is a polished surface. Calcitic rhombs are particularly well seen in Plate III—6 which is an enlargement of one of the spheroliths seen in Plate III—3. The angle of the joint planes constituting the calcitic rhombs in Plate III--6. are reminiscent of the herring bone structure found in some sauropod egg shells (Erben, 1970). On the mammillary surface clusters of well developed mammillae can be observed (Plate III—7). These are sub-circular in shape and show overlapping between adjacent mammillae. This indicates subsequent activation of the membranea testacea so that the younger formed mammillae overlap the older developed ones. On the external surface, prominent node-like structures are present.

AFFINITIES

The affinities of the Nagpur and Asifabad egg shells are hard to determine, even though the number of specimens is fairly large, the state of preservation is fairly good and the internal and external structure is similar in part to that described for recent and fossil reptiles and birds. The main factors that make a taxonomic assignment difficult is the fact that comparatively few non-dinosaurian, fossil egg shell remains have been described from the Cretaceous-Tertiary horizons, the egg shell structure of dinosaurs, birds, lizards, crocodiles and turtles may have been more similar to each other in the Cretaceous than can be ascertained today, and in screened material there is no certainty in the association of the egg shell fragments to the parent animal. Comparison can only be made with the structure of recent eggs of the reptilian and avian groups cited above and even these have not been fully studied (Hirsch, 1983).

In external sculpturing, all the egg shell fragments from both localities can be compared to those of dinosaurs. The tuberculated nodose and lophate ornamentation is exactly similar to that described for dinosaurs (Erben, 1970; Sahni, 1972; Hirsch, 1979; Sahni and Gupta, 1982). Tuberculate or nodose ornamentation is not commonly found in recent re-

ptilian or avian egg shells. Hirsch (1979) states that the nodose condition is found in some Oligocene birds. A few recent snakes and lizards have some node-like structures (Hirsch pers. comm.). Crocodiles are not known to have any external sculpturing. In transverse section, the extreme thinness of the egg shells is far below that commonly known for dinosaurs (Table 1) and is at present the biggest obstacle in assigning the egg shells to the Dinosauria. Thickness may not be a conclusive factor in taxonomic placement, but yet it can not be disregarded. At present, it is not possible to be sure whether the thin egg shells are because of pathologic conditions (Erben, 1970 or in fact represent the "normal" egg shells of a small species of dinosaurs or some other reptile or bird. While the thinness of the egg shell suggests affinities with lizards, crocodiles and birds, the morphology of the egg shells can not be conclusively related to any of these groups, though a number of similarities exist. In *Hemidactylus* (lizard) (Packard *et al.*, 1982), similar vertical calcite wedge-like structures are observed as are present in the Nagpur specimens. The general morphology of the egg shells (and incidentally the thickness) is similar to bird egg shells, known from the Plio-Pleistocene Karewa deposits of Kashmir (Sahni *et al.*, in press). Though the internal structure, especially the basal tabular aggregates resemble that known for crocodiles, the mammillary structure is quite different and hence this group can be eliminated. The remains of crocodiles are not known at Asifabad while this group may be represented by only a few teeth in Nagpur.

In transverse section, the Asifabad egg shells (Pl. III—3 and 4) are similar to sauropods in external sculpturing, structure of the spheroliths and the mammillary surface. Except for thinness of the egg shells, no other feature mitigates against assigning them to the dinosauria. The structure of the mammillary surface also suggests dinosaurian or avian affinities. The mammillae are extremely well developed in all of the egg shells.

The environmental conditions both at Nagpur and Asifabad represent lacustrine or lagoonal conditions with minor fluvial inputs. The presence of rays, tetraodonts, foraminifera and marine algae suggest marine influxes. At Asifabad, where the thickness of the intertrappeans is more than that of Nagpur, the egg shells are recovered from both the upper and lower horizons which represent brackish water as well as freshwater conditions. In general, the associated microfossils in both localities are the same and consist of charophytes, cyprid ostracodes, unionid pelecypods and pulmonate gastropods. Surprisingly, in the mainly Plio-Pleistocene Karewa deposits, thin egg shells related to birds are found with a similar microfossil assemblages.

In conclusion, the affinities of the investigated egg shells cannot be determined with certainity. Morphologically, the Asifabad specimens are closest to dinosaurs. The Nagpur fragments including a few from Asifabad, may be either avian or lacertilian.

Recently, one of us (A. S.) has discovered a widespread dinosaur hatchery at Bara Simla Hill, Jabalpur. Egg Shells are distributed in a 4 sq. km. area above the lower limestone horizon and consist of numerous *in situ* nests containing up to 9 eggs. The larger sample makes it possible to state that both types of egg shells found at Kheda Gujarat are present at Jabalpur.

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REFERENCES

ALEXANDER, P. O. 1981. Age and duration of Deccan Volcanism: K: Ar evidence. *Mem. Geol. Soc. India.* **3** : 244-258.

BANDE, M. B., PRAKASH, U. AND BONDE, S. D., 1981. Occurrence of *Peyssonnelia* and *Distichoplax* in Deccan Intertrappeans with remarks on the age of Chhindwara traps and palaeogeography of the region. *Geophytology*. **11**(2) : 182-188.

BHATIA, S. B. AND MANNIKERI, M. S. 1976. Some charophyta from the Deccan Intertrappean beds near Nagpur, Central India. *Geophytology*. **6**(1) : 75-81.

BHATIA, S. B. AND RANA R. S. 1983. Palaeogeographic implications of the Charophyta and ostracods of the Inter-trappean beds of peninsular India. Asia symposium, Oct. 17-20, in Paris (In press).

CHOW, M. C. 1951. Notes on the Late Cretaceous dinosaurian remains and the fossil eggs from the Laiyan, Shantung. *Bull. Soc. China.* **31** (1-4) : 89-96.

CHOW, M. C. 1954. Additional notes on the microstructure of the supposed dinosaurain egg shells from Laiyang, Shantung. *Sci. Sinica.* **3**(4) : 523-525.

DUGHI, R. AND SIRUGUE, F. 1957. Les Oeufs de dinosauriens du bassin d' Aix-en-provence. *C. R. Acad. Sci. Paris.* **245** : 707-710.

DUGHI, R. AND SIRUGUE, F. 1958. Observation sur les oeufs de dinosaures du bassin d' Aix-en-provence: le oeufs a coquilles bistratifiees. *C. R. Acad. Sci. Paris.* **246** : 2271-2274.

DUGHI, R. AND SIRUGUE, F. 1959. Sur des fragements de coquilles fossiles dans 1' Eocene de Basse-provence. *C. R. Acad. Sci. Paris.* **249**(D) : 959-960.

DUGHI, R. AND SIRUGUE, F. 1962. Distribution verticale des oeufs d' oiseaux fossiles de 1' Eocene de Basse provence. *Bull. Geol. Soc. France.* **7**(4) : 69-78.

DUGHI, R. AND SIRUGUE, F. 1966. Sur la fossilisation de oeufs de Dinosaures. *C. R. Acad. Sci. Paris.* **262** (4) : 2330-2332.

DUGHI, R. AND SIRUGUE, F. 1976. L' and extinction de dinosaures a la lumiere des gisements d'oeufs due Cretace terminal du sud de la France, principalement dans le Bassin d' Aix-en-provence. *Paleobio. Continentale.* **7**(1) : 1-39.

ERBEN, H. K. 1970. Ultras truktur and Mineralisation rezenter und fossiler Eischalen bei Vogeln und Reptilien. *Bominer. Res. Repts.* **1** : 1-66.

ERBEN, H. K., ASHRAF, A. R., KUMSIEK, K. AND THEIN, J. 1983. Some dinosaurs survived the Cretaceous "Final Event". *Symposium Influence of Geologic Processes on evolution of life.* Abstract No. 1.

HIRSCH, K. F. 1979. The oldest vertebrate egg ? *Jour. Palaeont.* **53** : 1068-1084.

HIRSCH, K. F. 1983. Contemporary and fossil chelonian egg shells. *Copeia.* **2** : 382-397.

HORNER, J. R. 1982. Evidence of colonial nesting and site fidelity among orinithischian dinosaurs. *Nature.* **297** (5868) : 675-676.

JENSEN, J. A. 1966. Dinosaur eggs from the Upper Cretaceous North Horn Formation of Central Utah. *Brigham Young. Univ. Geol. Stud.* **13** : 55-67.

JEPSEN, G. L. 1931. Dinosaur egg shell fragement from Montana. *Science.* **73**(1879) : 12-13.

LYDEKKER, R. 1890. Note on certain vertebrate remains from the Nagpur District. II part of the chelonian plastron from Pisdura. *Rec. G. S. I.* **23** : 22-23.

MOHABAY, D. M. 1984. The study of dinosaurian eggs from Infratrappean Limestone in Kheda District, Gujarat. *Jour. Geol. Soc. India.* **25**(6) : 329-337.

PACKARD, M. J., PACKARD, G. C. AND BARDMAN, T. J., 1982. Structure of egg shells and water relation of reptilian eggs. *Herpetologica.* **38** : 136-155.

PARKASH, U. 1960. A survey of the Deccan Intertrappean flora of India. *Jour. Palaeot.* **34**(5) : 1027-1040.

RAO, B. R. J. AND YADAGIRI, P. 1979. Cretaceous Intertrappean beds from Andhra Pradesh and their stratigraphic significance. *Geol. Soc. India. Mem.* **3** : 287-291.

RANA, R. S. 1984. Microvertebrate palaeontology and biostratigraphy of the Infra and Intertrappean beds of Nagpur, Maharashtra. *Unpub. Ph. D. Thesis, Panjab. Univ.* Chandigorh. 1-238.

SAHNI, A. 1972. The vertebrate fauna of Judith River Formation Montana. *Bull. Amer. Mus. Nat. Hist.* **147**(6) : 323-412.

SAHNI, A. 1983. Upper Cretaceous palaeobiogeography of peninsular India and the Cretaceous-Palaeocene transition: The vertebrate evidence. *Palaeo. Symp. B. S. I. P. B.* Lucknow. 128-140.

SAHNI, A. AND GUPTA, V. J. 1982. Cretaceous egg shell fragments from the Lameta Formation, Jabalpur, India. *Bull. I.G. A.* **15**(1) : 85-88.

SAHNI, A., KUMAR, K., HARTENBERGER, J. L., JAEGER, J. J., RAGE, J. C., SUDRE, J. AND VIANEY-LIAUD, M. 1982. Microvertebres nouveaux des Trapps du Deccan (Inde): Mise en evidence d'une voice de communication terrestre probable entre la Laurasia et l' Inde a la limite Cretace-Tertiare. *Bull. Soc. Geol. France.* **24**(5-6) : 1093-1099.

SAHNI, A., GUPTA, V. J., SHARMA, B. P. AND KOTLIA, B. S. 1984. Fossil bird egg shell fragments from Karewas of Kashmir valley (J & K), India: A Scanning Electron Microscopy study. *Jour. Pal. Soc. India., Lucknow* Communicated.

SAHNI, B. 1934. The Deccan Trap: Are they Cretaceous or Tertiary? *Curr. Sci.* **3**(4) : 134-136.

SAHNI, M. R. 1957. A fossil reptilian egg from the Uttattur (Cenomanian) of South India, being the first record of a vertebrate fossil egg in India. *Rec. G. S. I.* **87**(4) : 671-674.

SOCHAVA, A. V. 1969. Dinosaurs eggs from Cretaceous of Gobi Desert. *Palaeo. Jour.* **4** : 517-527.

SOCHAVA, A. V. 1970. Mixtexture of dinosaur egg shell from the Lower Cretaceous of North Gobi. *Doklady Akademii Nauk* SSR. **192**(5) : 1137-1140.

SOCHAVA, A. V. 1971. Two types of egg shell in Cenomanian Dinosaures. *Palaeo. Jour.* **3** : 353-361.

SRIVASTAVA, S. 1983. Excavation of dinosaurs bones in the Lameta beds near Rahioli, Kheda District, Gujarat. *G. S. I. News Western Region.* **2**(2) : 1-13.

VAN STRAELEN, V. 1928. Les oeufs de reptiles fossils. *Palaeobiologica.* **1** : 293-312.

VAN VALEN, L. AND SLOAN, R. E. 1977. Contemporatriety of the Late Cretaceous Extinctions. *Nature.* **270**(5633) : 193.

WENSINK, H., BOELRIJK, N. A. I. M., HEBEDA, E. H., PRIEM, H. N. A., VERDURMEN, E. A. T. AND VERSCHURE, R. H. 1979. Palaeomagnetism and radiometric age determinations of Deccan Trap, India. *IV. Int. Gond. Sympl. Calcutta.* **2** : 832-841.

YOUNG, C. C. 1959. New fossil egg from Laiyang, Shantung. *Vertebr. Palasiatica.* **3** : 34-35.

YOUNG, C. C. 1965. Fossil eggs from Nanhsiung, Kwangtung and Kanchou, Kiangri. *Vertebr. Palaeo. Pecking Nat. Hist. Mus.* **9**(2) : 141-189.

YOUNG, C. C. 1979. Note on an egg shell from Ninghsia. (Abst) *Vertelsr. Palasiatica.* 17 : 311.

ZHAO, Z. 1979. Discovery of the dinosaurian eggs and foot print from Neixiang county, Henan province. *Vertebr. Palsiatica.* (Abst.), **17** : 309.

EXPLANATION OF PLATES

PLATE I

The bar distance is equal to 25 μm in all plates.

NAGPUR EGG SHELL

1. External surface view showing irregularly ridged and tuberculate surface.
2. Longitudinal section.
3. Longitudinal section.
4. Longitudinal section, showing well developed spheroliths.
5. Longitudinal section, showing well developed spongy layers.

PLATE II

1 & 2. Longitudinal section, showing spongy layer.
3. Longitudinal section, showing spheroliths with mammillae.
4. Mammillary surface view.
5 & 6. Mammillary surface, showing well developed tabular and spicular crystal aggregate.

PLATE III

ASIFABAD EGG SHELL

1, 2, 3 & 4. Longitudinal sections, showing well developed spheroliths.
5. External surface, showing ridges and grooves.
6. Longitudinal section, showing herring-bone structure.
7 & 8. Mammillary surface, recrystallized mammillae, tabular and spicular crystal aggregate are well developed.