Himalaya[16]. Palaeomagnetic studies also support such an interpretation. Recent palaeomagnetic data[17] for the northwestern Himalaya put the time of the India–Asia collision at ~60 Ma or even close to the K/T boundary as supported by palaeontological evidence for some link between India and Asia at that time[18,19]. Palaeomagnetic data for the eastern Himalaya demonstrate later collision at 45–50 Ma[20].

Assuming an early collision of the Indian plate on its northwestern margin close to the K-T boundary, an interesting point emerges from Figure 2. The peak of hornblende ages at 35–45 Ma for the northwestern Himalaya indicates that crustal thickening associated with the collision and subsequent thermal acme of the regional metamorphism were reached shortly after the collision. This interpretation has been given for the Indian plate crystalline stack in the Pakistan Himalaya[21]. The hornblende ages we report here for the HHC rocks in Zanskar agree with such a thermal history and can be explained considering the very fast drift of the Indian plate during the Cretaceous (18–20 cm/yr compared to the present rate of 4–5 cm/yr) and the substantial decrease in the drift rate during early Tertiary[17,20].

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ACKNOWLEDGEMENTS. This study was undertaken while R. B. S. was in Kyoto University, Japan. He would like to thank all friends in the Department of Geology and Mineralogy, Kyoto University, for kind hospitality, and members of the field party from University of Roorkee for a joyful trip to Zanskar.

Received 25 September 1992; accepted 30 September 1992

Ornithoid eggshells from Deccan intertrappean beds near Anjar (Kachchh), Western India

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We describe here the ornithoid eggshell fragments from the Deccan intertrappean beds (Late Cretaceous) near Anjar, district Kachchh, Gujarat. The find assumes palaeobiogeographic significance as morphologically similar eggshells are known from the Late Cretaceous Nemegt Formation of Mongolia. Taxonomic affinities (dinosaurian/avian) of these eggshells cannot be established at present.

DOCUMENTATION of dinosaur (sauropod) egg clutches from Late Cretaceous Lameta Formation of central and western India has increased considerably in recent years[1–5]. However, the record of ornithoid (or avian-like[6]) eggshells was so far restricted to Pleistocene deposits where they have been referred to the ostrich *Struthio* cf. *S. asiaticus*[7]. Here we describe such eggshells from the Deccan intertrappean beds at a locality about 1.5 km SE of the village Viri (23° 4′ 50″ N: 70° 30′ E) near Anjar, district Kachchh, Gujarat (Figure 1). This record, of which a brief mention was recently made[8], follows the discovery of dinosaur bones in the same general area[9].

The eggshell-yielding bed comprises dark grey splintery shale containing stringers of chert. In the local flow stratigraphy[9], it occurs between the third and fourth lava flows, representing the third intertrappean level in the area (Figure 1). Screen-washing of these shales yielded a diverse assemblage of eggshell fragments including those of sauropod dinosaurs and geckonid lizards, besides the most abundant ornithoid

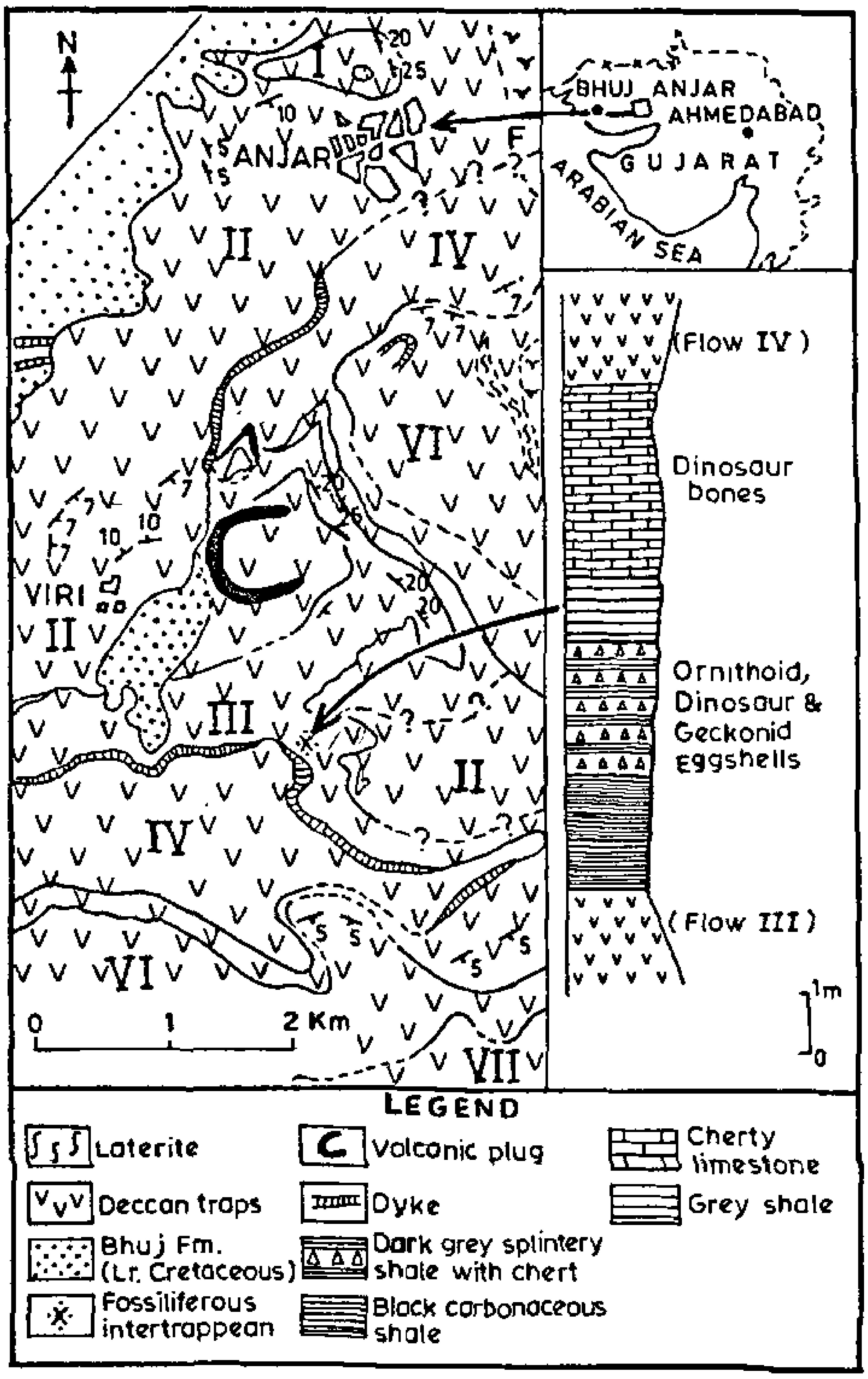
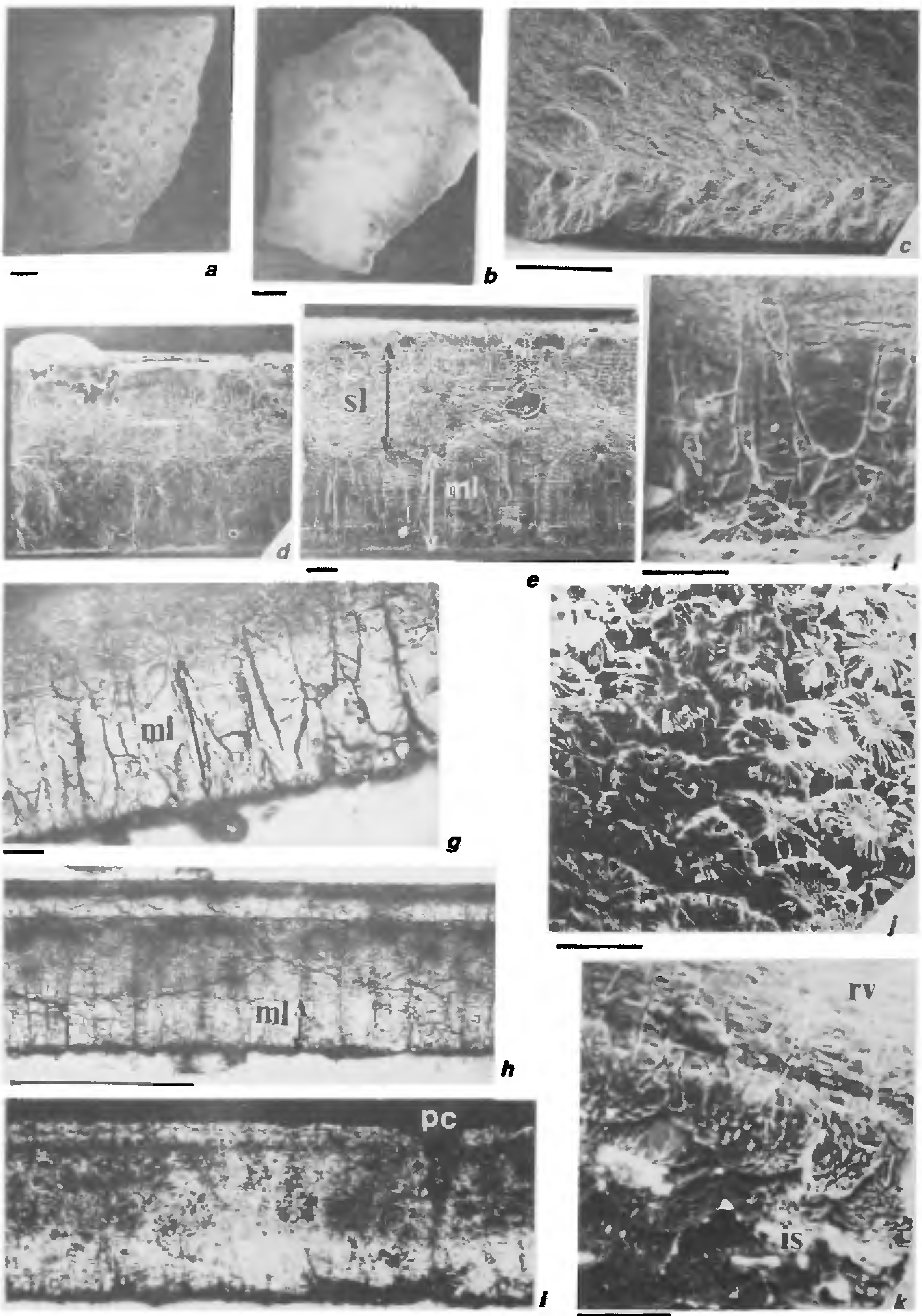


Figure 1. Geological map of the Anjar area and lithostratigraphic section at the collecting locality (map from Ghevariya, 1988).

eggshells. In addition, isolated theropod tooth, fishes including dasyatids, percoid otoliths, microlamellibranchs and gastropods were recovered from this lithounit. Fragmentary dinosaur bones occur at the top of this intertrappean sequence in the area[8–10]. The assemblage suggests a Late Cretaceous (Maastrichtian) age based on correlation with similarly dated dinosaur-bearing intertrappeans of western Kachchh, Nagpur, Asifabad and Jabalpur[5,8,11,12]. The contrary suggestion of an Early Palaeocene age[10] for the third intertrappean sequence (ornithoid eggshell bearing) is not tenable in the absence of data on palynofossil assemblages, absolute ages (^{40}Ar–^{39}Ar) and palaeomagnetic measurements from Anjar. Also, the reported presence of ornithischian eggs and clutches in the second intertrappean level in the area[10] remains unconfirmed as no details of these eggs are as yet published.

The present eggshell sample consists of about 300 fragments of which the largest measures about 30 mm^2. No complete egg has as yet been found. The thickness of these eggshells varies between 0.35 mm and 0.45 mm excluding a thin secondary deposit present on most fragments. Their outer surface is characterized by irregularly spaced, isolated tubercles with no distinct orientation, although clusters of 2 or more tubercles are also found in some fragments (Figure 2 *a*, *b*). In radial thin sections (Figure 2 *g–i*), the presence of two layers, an inner mammillary layer and an outer spongy layer (or continuous/single layer), is clearly seen. The mammillary layer varies in thickness from one-third to slightly less than one-half of the total shell thickness. It consists of tightly packed, slender mammillary cones with radiating crystallites. The spongy layer is well differentiated from mammillary layer but shows no well-defined structural pattern. Consequently, shell units are distinct only in the mammillary layer. Viewed under SEM (Figure 2 *d–f*) the mammillary layer consists of petal-like crystalline structures rising from the mammillary core. The spongy layer lacks any well-defined pattern but in rare instances, it shows some faintly developed columnar structures. In one instance, widely spaced horizontal layering (? growth striations) was observed (Figure 2 *e*). No pores were found on the outer surface. In radial sections also, no pore canal could be seen except in one instance (Figure 2 *i*) where a short, nearly straight canal tapering inwards was found. In configuration, it appears to correspond to the angusticanaliculate type of pore pattern[13,14]. The inner surface is diagenetically altered in most cases and consists of coarse crystalline structure. In a few instances, however, it shows excellently preserved mammillary knobs (Figure 2 *j*, *k*). These are circular or polygonal in shape and are tightly packed with negligible intermammillary spaces. The mammillae vary in diameter from 0.03 mm to 0.05 mm and in a majority of cases (where preserved) they are cratered.

The ever-increasing documentation of Late Cretaceous eggshells from peninsular India makes it necessary to classify the known material in a manner which would reflect the variability of various structural parameters of eggshells. Recently, we[15] have distinguished five eggshell types collectively from the Lameta Formation and intertrappean beds. Three of these, designated as (?)TST-I, (?)TST-II, (?)TST-III, are attributable to titanosaurid dinosaurs, although the evidence of embryonic remains or hatchlings is still awaited. Of these, (?)TST-I and (?)TST-III are exemplified by the eggshell material from Kheda[2] described as Kheda Type A and Kheda Type B respectively. The fourth eggshell type (Indet. Dinosauria) also shows sauropod-like shell units but is extremely thin (less than 0.4 mm). Such eggshells were first described from Asifabad intertrappeans[16]. A recent record[17] from the Lameta Formation of Nand area is probably referable to the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same category, although detailed description and illustrations of the Nand eggshells have yet to be published.

The ornithoid eggshells described here constitute the fifth eggshell type known from peninsular Cretaceous sequences. These eggshells can easily be assigned to Ratite morphotype[18] in which the shell structure is characterized by two layers (mammillary and spongy layers) and the shell units are discrete only in the mammillary layer. Elsewhere in the world the Cretaceous records of such eggshells are mainly known from Mongolia, China and Kazakhstan and a number of *parataxa have been proposed to classify them*[18]. Originally, these avian-like eggshells were described as 'angusticanaliculate' type and were sought to be related to ornithischian dinosaurs[6,13], an interpretation later supported by other workers[14]. On the other hand, a more recent viewpoint[18] favours taxonomic attribution of part of the angusticanaliculate eggshell material (family Elongatolithidae) from Mongolia and China to theropod dinosaurs. Judging from illustrations, these eggshells are distinguishable from the Anjar material in the details of surface sculpture and in being thicker (maximum by over 4 times). Similarly, the ornithoid-ratite eggshells (? *Troodon*) reported from the Upper Cretaceous (Campanian) Two Medicine Formation of Montana[19], can be distinguished from the present specimens in being much thicker (average thickness 1–2 mm), in having a considerably thinner mammillary layer (1/10 to 1/12 of shell thickness) and in a pronounced change from the mammillary to spongy layer. In these respects the 'avian-like' eggshells from Montana[19] compare favourably with the Anjar eggshells, although they have a smooth outer surface.

The Anjar eggshells compare most closely with the two new ornithoid families, Laevisoolithidae and Subtiliolithidae, recently described from the Late Cretaceous Nemegt Formation of Mongolia[18]. However, the outer suface of Laevisoolithid eggshells is smooth and the mammillary layer in the family Subtiliolithidae is 2 to 3 times as thick as spongy layer.

In conclusion, the ornithoid eggshells from Anjar probably represent one of the two above-mentioned *parataxa from Mongolia, or a closely related* group. Taxonomic assignment of these eggshells can be made only after embryonic remains or hatchlings are found. As of now, this find is significant not only in terms of enhancing the diversity of Late Cretaceous eggshell record from India but possibly also because it further emphasizes the now well-established Asiatic character of intertrappean biotas[20].

Repository: The material is stored in Vertebrate Palaeontology Laboratory, Department of Geology, Panjab University, Chandigarh.

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ACKNOWLEDGEMENTS. This study benefited considerably from correspondence with Dr Karl F. Hirsch who also provided the much needed comparative material out of his personal collection. Dr (Mrs.) Neera Sahni took SEM photographs for which we extend our sincere thanks to her. S. B. and S. S. thankfully acknowledge funding by the CSIR, New Delhi.

Received 25 August 1992; accepted 3 October 1992

Figure 2. Ornithoid eggshells. *a–c*, outer surface (SEM); *d*, *e*, radial views (SEM, fractured surface); *f*, enlarged mammillary cones ◀ (SEM); *g–i*, radial thin sections; *j*, inner surface (SEM); *k*, inner surface and lower part of radial section (SEM). Bar equals 500 μm for *a–c*, *i* and 50 μm for *d–g*, *j*, *k*. Abbreviations: is, inner surface; ml, mammillary layer; pc, pore canal; rv, radial view; sl, spongy layer.