

ent level, the plants and animals of Kaveri River maintained varying degrees of concentration of the four radionuclides and ^{210}Po displayed maximum accumulation. High accumulations of ^{210}Po relative to other nuclides are seen in all the organisms under study. From the data in Table 2, significant intake of ^{210}Po among fish/shellfish-eating population may be anticipated due to relatively more ^{210}Po levels in the organisms, particularly in the edible parts of the muscle. Conversely, higher concentrations of ^{210}Pb , ^{226}Ra and ^{228}Ra are evident significantly in the shell. The muscle of prawn and fish are also sites of accumulation of ^{210}Pb , ^{226}Ra and ^{228}Ra as they are for ^{210}Po , but their levels are relatively much lower. The higher concentration of ^{210}Pb , ^{226}Ra and ^{228}Ra in shells and bones of aquatic organisms may be linked to their capacity to replace calcium. The concentration factors (CFs) for ^{210}Po are in the range of 10^3 – 10^4 with the fishes displaying low levels. The CFs of ^{210}Pb , ^{226}Ra and ^{228}Ra in comparison to ^{210}Po in the same organism are generally found to be less by a factor of 10 or even 100 in some cases and ranged from 10 to 10^3 . The results of ^{210}Po , ^{210}Pb , ^{226}Ra and ^{228}Ra accumulation in some of the environmental matrices reported here are higher than the concentrations reported in certain other normal background radiation areas^{8,9}.

Another interesting observation was the higher concentration of these radionuclides in the abiotic and biotic components of impounded water rather than in a running water environment. This could be due to the settlement of radionuclide-rich silt and organic matter and interaction of the biotic components with the sediment and higher biological production of an impounded water body. Higher concentrations of ^{210}Po and ^{210}Pb in the environment indicate higher inputs from the atmosphere and land run off of these radionuclides, since the main source of ^{210}Po and ^{210}Pb entering the environment is the exhalation of ^{222}Rn from the ground and its subsequent decay in the atmosphere. This results in ^{210}Po and ^{210}Pb deposition on the earth's surface and higher concentrations of ^{228}Ra radionuclide in water and sediment indicating higher thorium-bearing minerals in soil/or weather rock. Gamma spectrometry of the primordial radionuclides indicated a higher level of ^{232}Th activity (45 Bq/kg) than ^{238}U activity (15 Bq/kg) in Kaveri River sediment.

This study has established the level of background radiation in Kaveri River environment. The extensive studies covering the natural radiation aspects in the area have become evident for the possible external and internal exposure of the local population. The data presented here indicate that the nuclides contribute a substantial fraction of the total environmental dose to fauna.

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ACKNOWLEDGEMENTS. We thank the Board of Research in Nuclear Sciences, Department of Atomic Energy for funding the research project.

Received 17 November 1995; revised accepted 8 February 1996

Significance of the first record of nautiloid from the Upper Cretaceous Bagh Group of rocks

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The significance of the first record of an eutrophoceratid nautiloid in the Upper Cretaceous Bagh Group is evaluated here. Since nautiloids are truly oceanic in habit, their rarity is perhaps due to deep inland nature of the Bagh sea.

THE Upper Cretaceous Bagh Group, represented by shallow marine carbonates¹, is overlain by the Lameta Group or Deccan Trap and underlain by the Nimar Group or the Precambrian Crystallines. The outcrops of these rocks, although disconnected, show a parallel alignment to the course of the river Narmada and are concentrated in its northern flank (Figure 1). It is generally accepted that the Narmada–Son trend (WNW–ESE) is a tectonic lineament and represents a mid-continental rift from the Precambrian times², being associated with the Karoo rift system³. It has been reactivated many a time during the Phanerozoic, including the Upper Cretaceous, and is still active. The marine Bagh Group of carbonates were deposited in this narrow belt of inland sea bound by the rift complex and represent an aulacogen³.

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The Bagh Group consists of two formations (Figure 2). The lower Nodular Limestone Formation is divisible into three subunits. The basal subunit is a plane laminated lime mudstone. The middle subunit bears a recognizable nodular character and overlies the basal subunit rather sharply. The topmost subunit (marly) is distinctly nodular and contains a higher proportion of argillaceous material in the form of clay seams wrapped around the limestone nodules. It rests on a planar, bored hardground just top of the middle subunit. These two formations are separated by another planar, bored hardground.

These detached marine carbonate inliers have yielded different fossil groups like echinoids, bivalves, cephalopods, and bryozoans. Since the earliest collection by Keatinge and Blackwell in 1857, many workers⁴⁻¹⁴ have studied the fossil fauna of this group of rocks. However, none has reported occurrence of nautiloids in these rocks. This group, otherwise, is an important faunal element of the Cretaceous deposits throughout the world, including other basins of India.

Recently, during field work at Rampura (22°17'30"; 74°46') near Bagh Caves, we collected a single specimen of an eutrephoceratid nautiloid from the topmost subunit of Nodular Limestone Formation (Figure 3) which raises the question why they are so rare in Bagh.

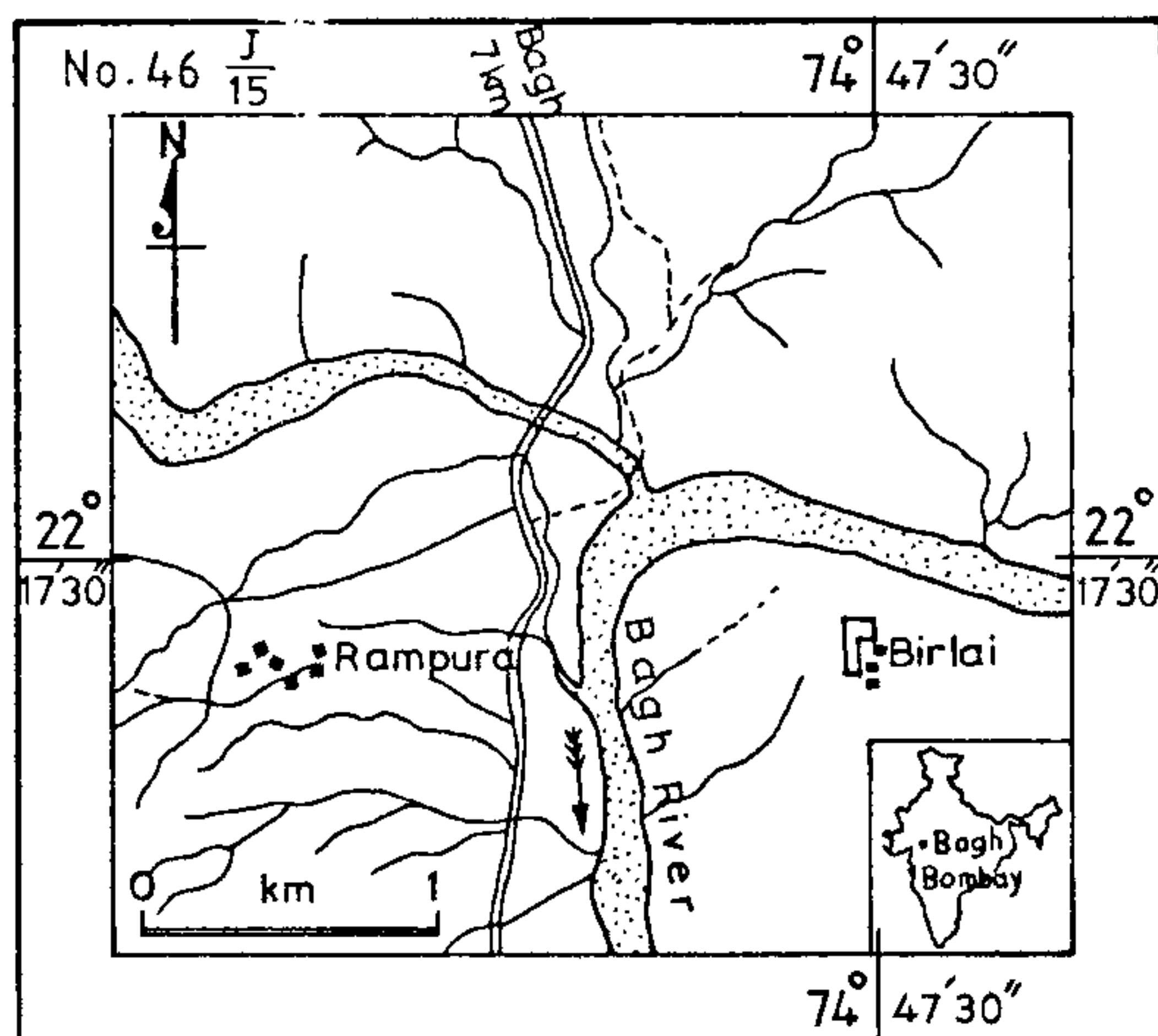


Figure 1. Location map of Bagh Group of rocks.

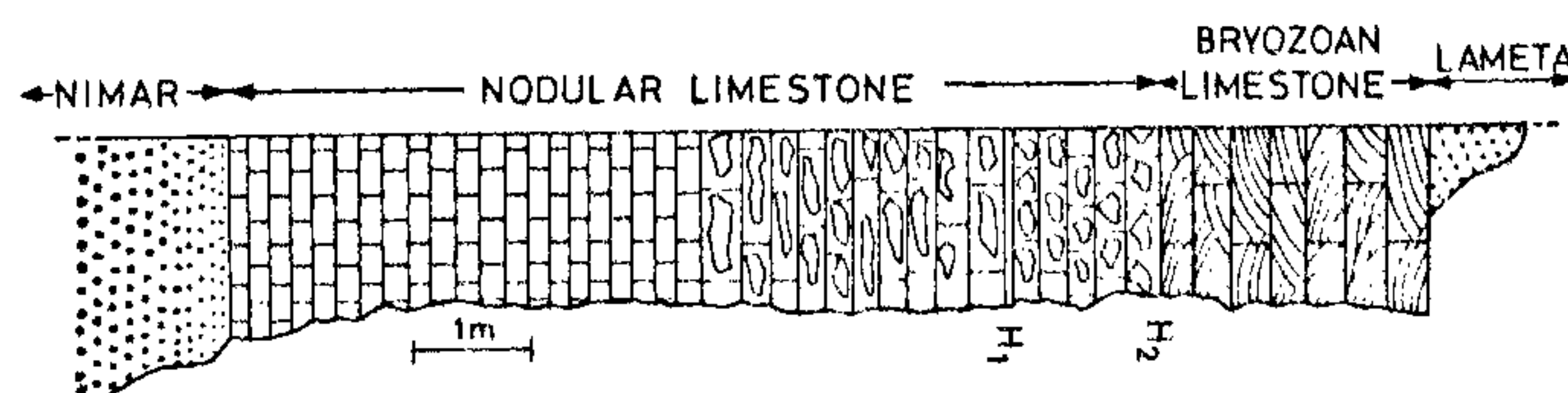


Figure 2. Complete measured section of Bagh Group of carbonates at Rampura. H₁, H₂, Hard grounds.

Systematic palaeontology

- Superfamily : Nautilaceae de Blainville, 1825
 Family : Nautilidae de Blainville, 1825
 Genus : *Eutrephoceras* Hyatt, 1894
 Type species : *Nautilus dekayi* Morton, 1834

Eutrephoceras sp. (Figure 4)

Material: Single specimen being internal mould, still septate, has been collected from the uppermost part of the Nodular Limestone Formation at Rampura, Dhar Dt., Madhya Pradesh and is kept in the museum of the Department of Geological Sciences, Jadavpur University, Calcutta.

Description: Shell small, maximum diameter observed 58 mm, septate, immature, involute, relatively slowly widening with somewhat rounded to slightly depressed whorl section. Umbilicus narrow small; laterals strongly arched; venter broadly arched. Whorl section rounded. Septa relatively widely spaced (seven in half whorl). Suture almost straight with very shallow lateral and ventral lobes. Siphuncle situated at a high position below one third height of the septum from the venter. Surface smooth on internal mould.

Discussion: *Eutrephoceras* is ubiquitous and ranges in time from the Upper Jurassic to Middle Cenozoic¹⁵. It is the most common post-Triassic nautiloid. The genus generally has a tightly involute, subglobular, smooth conch with nearly straight sutures. However, there occurs wide interspecific variability in conch shape, degree of involution and inflexion of sutures. These perhaps suggest wide adaptive realm for this genetic stock.

The present form seems to be close in apertural outline to two Cretaceous forms, namely *Eutrephoceras dekayi* (Morton) from USA and *E. laverdei* Durham from Colombia. All the forms seem to be involute and have somewhat rounded and depressed aperture. In Upper Cretaceous, *E. dekayi* position of siphuncle varies ontogenetically, being lower in early ontogeny and above the centre in later ontogeny. In Aptian *E. laverdei*, it is centrally placed¹⁶.

Blanford¹⁷ described many nautiloid species from Upper Cretaceous marine rocks of Trichinopoly basin, some of which belong to *Eutrephoceras*. The present specimen resembles some of the variants of 'Nautilus'



Figure 3. Photograph showing the Bagh Group of carbonates at Rampura. Arrow indicates the exact position in the topmost subunit of Nodular Limestone Formation from where the specimen has been collected.

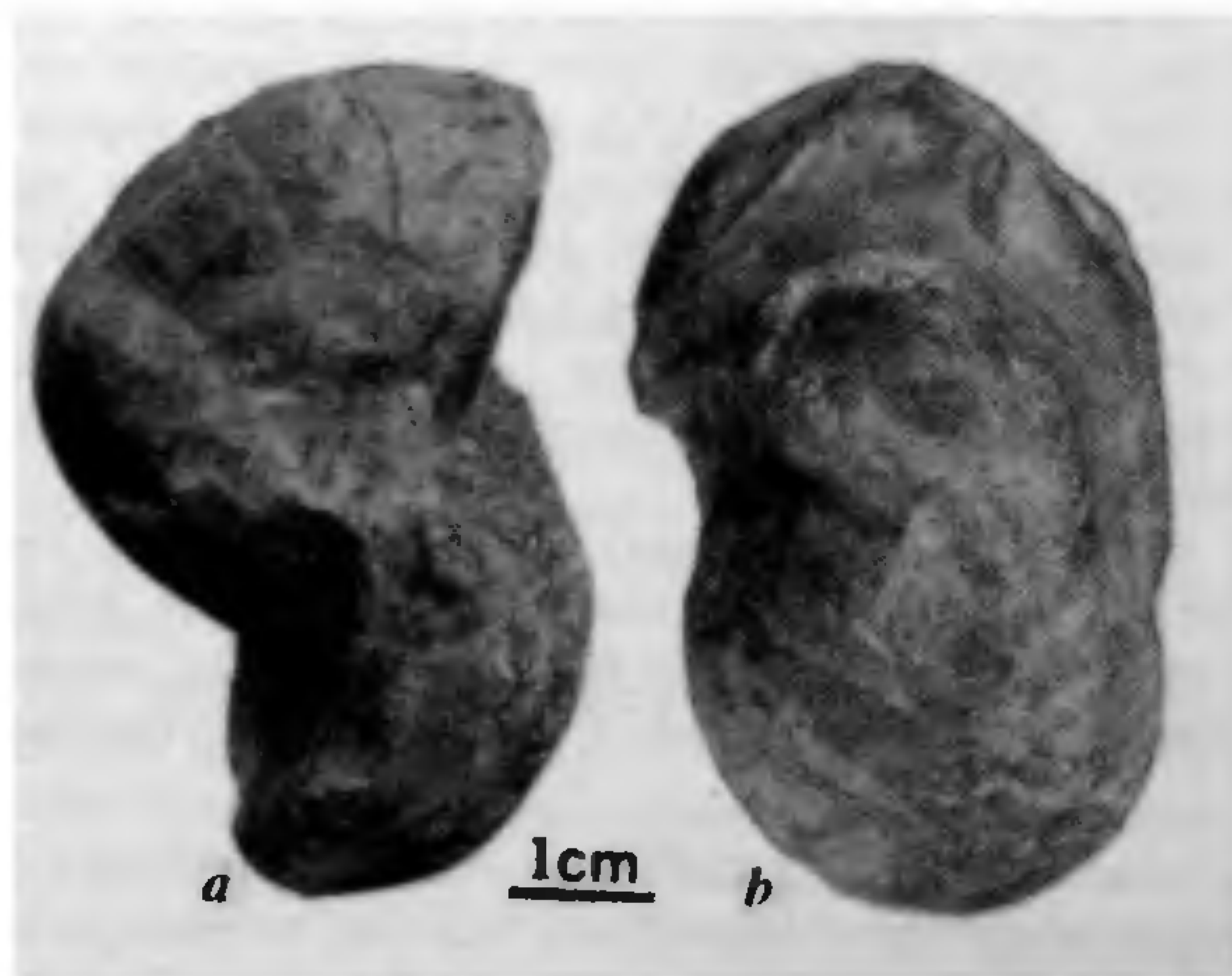


Figure 4a, b. Lateral and ventral views of *Eutrephoceras* sp.

bouchardianus d'Orb.¹⁷, of Arialoor group, Trichinopoly district, in general shell shape and whorl outline, but the latter species being highly variable, is generally

more depressed and has sinuous suture. Besides, '*N.*' *bouchardianus* is characterized by larger umbilicus and dense ribbing in early ontogeny. The present specimen has close correspondence with '*Nautilus*' *elegans* D'orb. found from Trichinopoly group in different localities of Trichinopoly district and particularly shows strong similarities with an internal mould of the latter species¹⁷. Both the species have similar apertural outline, number of septa per whorl and position of siphuncle. But '*N.*' *elegans* is an ornamented form characterized by dense ribbing with slightly evolute perforated umbilicus. Moreover, it perhaps comes from a lower stratigraphic level. '*Nautilus*' *rota*¹⁷ found from the lower part of Arialoor group of Trichinopoly, resembles the present form in young stage in having smooth shell but can be distinguished by its compressed whorl section, more ventrally placed siphuncle and much more sinuous suture. However, '*N.*' *rota* has transverse ribs in adult stage and the species was later ascribed to the genus *Paracymatoceras*¹⁶.

The Bagh fauna, particularly of the Nodular Limestone Formation, bear the typical shallow marine signature. Nevertheless, nautiloids which are otherwise a part of the typical faunal element of the Cretaceous marine horizons of many places of the world^{15,16,18} are conspicuous by their absence.

The Bagh basin was restricted to the Narmada–Son lineament which is a deep-seated fault. During the Cenomanian flooding, this narrow belt bound by the rift complex was inundated and formed a deep interior sea-way where the carbonates were deposited.

Although the Bagh biostratigraphy suffers from precise zonation and age, recent report of inoceramids like *Inoceramus lamarcki* var. *cuvieri*, *I. lobatus* indicates Senonian age¹⁰ for the Nodular Limestone Formation and recent recognition of pandemic ammonite species, *Placentoceras kaffrarium*¹⁹ from all the subunits of the Nodular Limestone Formation at Rampura indicates Coniacian age²⁰ for the Nodular Limestone Formation.

The presence of *Placentoceras tamulicum*, now reclassified as *Placentoceras kaffrarium*²⁰, in the Trichinopoly stage of the Cauvery basin in the east coast of Indian peninsula points to close similarity in age of the Nodular Limestone Formation of Bagh and the Trichinopoly stage of the Cauvery basin.

Palaeobiogeographic distribution of nautiloids indicates that post-Palaeozoic nautiloids were truly oceanic in habit and mainly restricted to the continental platform margin^{15,21}. The only surviving nautiloid genus, *Nautilus* is confined to the oceanic Indo-West Pacific faunal province between the Philippines and Samoa^{22, 23}. It lives in deep water, generally prefers an average depth of 300 m. *Nautilus* is very sensitive to temperature and flourishes best between 25 and 29°C and at normal salinity²³. Even 1–2° change in temperature is detrimental to it²². Bagh being an inland sea, was very shallow and perhaps physico-chemically more stressful than normal

open marine environment, and was not conducive for nautiloid living.

The individual groups within the Bagh taxa appear to be of high density but are less diverse. Ammonites previously believed to be taxonomically diverse, are now found to be almost monotypic represented mainly by *Placenticerias*¹⁹. The functional morphological study of this genus as well as sedimentary facies analysis indicate that they lived in very shallow waters^{24,25} and their monopolization of the Bagh basin as an opportunist species implies prevalence of physico-chemical stresses.

The only nautiloid specimen found, is a steinkern. Associated ammonites also show varying states of preservation. The horizon, where the specimen is recorded, is a condensed zone marked by hardground at several levels²⁶. Associated ammonites are often seen to be bored and internal moulds are even encrusted with epizoan oysters implying reworking. The eutrephoceratid specimen is a septate internal mould whose camerae are infilled with a matrix similar to the host sediment. Since the infilled material retains the shape of nautiloid, we suggest that sediments were cemented prior to diagenetic dissolution of aragonitic shell. But matrix was partly lithified when the shell dissolved as evident from a slight deformity of the specimen. The absence of body chamber in the present specimen, we believe, is due to mechanical destruction prior to burial²⁷. This also explains why infilling material is sediment and not calcitic spar which commonly occupy camerae of Bagh ammonites. Water with dissolved carbonates enters the cephalopod phragmocone through siphuncle. *Eutrephoceras*, characterized by siphuncle, is a deep-water form and preferred to live in the continental shelf²¹.

In conclusion, we attempt to establish that rarity of nautiloids in the Bagh basin may be ascribed to the deep inland nature of the sea which differed physico-chemically from the open oceanic environment. The only eutrephoceratid recorded, was perhaps posthumously transported from the open marine environment in a manner similar to the fate of a dead shell of extant *Nautilus*. The shell was later mechanically damaged, lost its body chamber and was finally buried within the Bagh sediment.

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ACKNOWLEDGEMENTS. We thank Dr S. Bardhan and Dr P. K. Bose of Jadavpur University; and Dr T. Lahiri of G.S.I for their valuable guidance in preparation of this article. T. K. G. thanks DST, New Delhi and K. H. thanks CSIR, New Delhi for financial support.

Received 21 September 1995; revised accepted 8 February 1996

Structural provinces of India based on gravity trends

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Gravity trend is defined as the axis of an elongated high or a low. Trends drawn from the Bouguer gravity anomaly map of India reveal that the Indian shield is a mosaic of about twelve crustal blocks that are either sutured or separated along the rift valleys. These blocks corroborate well with those identified earlier from geological evidences and provide a geophysical support to geological inferences.

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