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PALAEONTOLOGY OF THE BAGH BEDS PART IV: INOCERAMIDAE

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ABSTRACT

Our recent collections of fossils from the Bagh Beds have revealed a very rich and varied inoceramid fauna consisting of 34 species, among which 6 species and 5 subspecies are new. Being thus the most dominant single family among the Bivalvia occurring in these strata, it has an important bearing on the age, faunal affinities and stratigraphy of these rocks. The majority of these species point to Turonian as the appropriate age for them. While a large majority of the species, 22, among a total of 34, belong to *Inoceramus sensu stricto* which ranges from Lower Jurassic to Upper Cretaceous, presence of the subgenus *Sphenoceramus* though represented here by a single species, is of particular interest, because outside the Bagh Beds of Narmada Valley it is known to occur at horizons younger than Turonian.

INTRODUCTION

During our recent work on the Bagh fauna, no single group or family of bivalves has yielded such a rich variety, as the Inoceramidae. In view of their abundance in the Bagh Beds and because of the important bearing inoceramids in other regions are known to have on the problems of faunal affinities, age and stratigraphy, this group claimed our special attention, and has yielded valuable results.

Previous record of this family is very poor. Bose (1884) had listed 4 species, viz., *Inoceramus concentricus* Park., *I. coquandinus* d'Orb., *I. multiplicatus* Stol., and *I.* sp.; while Chiplonkar (1939) described, along with other bivalves, 4 species of this genus, viz., *I. pseudolatus* Chipl., *I. lamarcki* Park. var. *indicus* Chipl., *I.* sp. *A* and *I.* sp. *B* bearing affinities towards the Mediterranean palaeozoogeographic province.

Out of the 34 species now recorded by us, we describe here 6 species and 5 sub-species which are new to science. Our comments on the 23 species already reported from other regions and now found to occur among the Bagh fauna, will appear in another instalment to follow.

This family of bivalves is present in all the constituent members of the Bagh Beds, excepting the Nimar Sandstone, the basal member of the series. However, there are two distinct horizons in the Bagh succession where they are so abundant and crowded that they could be named as the Lower *Inoceramus* Bed and the Upper *Inoceramus* Bed. We have named them thus to ensure that this aspect of occurrence of these inocerami is not lost sight of, and future work in this direction may show whether or not these two beds could be treated as distinct units in the Bagh Stratigraphy. The lower bed comes at or near the top of the Nodular Limestone and the upper one occupies the top of the Deola-Chirakhan Marl (Chiplonkar & Badve, 1972a, pp. 93-94).

All the *Holotypes* of the species described here are preserved in the collection of the Maharashtra Association for the Cultivation of Science, Poona-4.

SYSTEMATIC DESCRIPTION

Order Pterioida Newell, 1995

Suborder Pterina Newell, 1965

Superfamily Pteriacea Gray, 1947

Family Inoceramidae Giebel, 1852

Genus *Inoceramus* Sowerby, 1819

Inoceramus (*Inoceramus*) *pronus* sp. nov.

(Pl. 1, Figs. 1 & 2)

Material. 3 specimens.

Holotype. No. Ram. 15.

Description. The shell is inequilateral, very tumid, narrow and conspicuously higher than long. The strong convexity of the valves and their high umbones almost meeting together give the shell a very characteristically arched appearance, which combined with its small length gives to the shell a discoid outline, the periphery of it appearing like a stout ridge. Surface on either side of this ridge is more flat than convex. The surface carries prominent concentric ridges separated by smooth concavities.

Dimensions. Angle* $\alpha = 106°$, $\beta = 45°$, $\sigma = 94°$

Remarks. This species can easily be distinguished from all the associated species by its very deep valves. Compared to the Upper Turonian German species *I. seitzi* Andert (Andert 1934, p. 123, pl. 16, Fig. 2) which also is similarly tumid, present species differs in being much more convex, by its anterior and posterior sides equally compressed and almost at right angles to the plane of contact of the two valves; concentric ridges more drawn out; ear much smaller and the ventral margin subequal to the dorsal margin.

Compared to *I. aduncus* Anderson (Anderson 1958, p. 100, Pl. 18, Figs. 11 & 12) from Turonian of Oregon and California again with similarly very tumid valves, our species is more convex, with sides anteriorly and posteriorly to the ridge flattened and concentric ridges regularly disposed.

Occurrence. From the base of the Nodular Limestone at Rampura and Chirakhan.

Inoceramus (*Inoceramus*) *unguliformis* sp. nov.

(Pl. 1, Figs. 5 & 6)

Material. 5 specimens.

Holotype. No. Si. 98/69.

Description. The shell is taller than long with umbones anteriorly curved, narrow and somewhat raised above the level of the hinge. A ridge acutely rounded and anteriorly slightly concave runs from the umbones to the ventral margin; part of the shell anterior to the ridge is at right angles to the plane of contact of the two valves. The valves together give the appearance of a hoof, and hence the name of the species.

The dorsal margin is produced into a distinct ear inclined posteriorly and merging suddenly into posterior margin. Ventral and posterior margins are broadly convex and merge into one another in an obtuse curve.

Surface is thrown into concentric folds, every third fold being more conspicuous than the two on either side. The folds and the depressions carry fine concentric ribs. The dorsal slope of the folds is almost as wide as the ventral slope but is slightly less steep.

Dimensions. Angle. $\alpha = 90°$, $\beta = 60°$, $\sigma = 132°$

Remarks. Present species and *Inoceramus eduncus* Anderson from the Turonian of Oregon and California (Anderson 1958, p. 100, Pl. 18, Figs. 11 & 12) have similarly convex valves; but characteristic difference exhibited by the American species is that its umbones are very strongly curved.

By its convexity, general tall nature with ear moderately developed, this species resembles *I. lamarcki* Park. (Woods 1911). But its acutely rounded ridge running from umbones to the antero-ventral margin and its surface anterior to it almost flat to feebly concave and meeting almost at right angles to the plane of contact of the two valves separates it from *I. lamarcki* Park.

Some of the individuals in our collection are less convex than others. But orientation of the surface to the ridge in relation to the plane of contact of two valves bring them all together.

Occurrence. Deola-Chirakhan Marl, Upper *Inoceramus* Bed at Sitapuri, Chirakhan, Bowarla, etc., and Upper Coralline Limestone at Sitapuri.

Inoceramus (*Inoceramus*) *subtrigonoides* sp. nov.

(Pl. 1, Fig. 7)

Material. One specimen.

Holotype. No. Ba. 47.

Description. Shell is inequivalve, inequilateral, trigonal, a little longer than high, and moderately tumid with strongly convex ventral margin. Surface is covered with well separated and prominent concentric folds with equally distinct concavities in between, and concentric striae on them. The umbones are rather pointed and markedly curved towards the anterior side.

Remarks. I. teshioensis Nagao & Matsumoto from the Turonian of Japan (Nagao & Matsumoto 1939, pl. 24, Figs. 5-7) is much like the present species, by its general outline, subcentral umbones, the left umbo considerably curved inwards and forwards and the general pattern of ornamentation. However, the present species has its shell distinctly longer and slightly compressed near postero-dorsal margin, the point of its maximum length more ventrally situated, its ear relatively shorter and the angle between the hinge and the anterior margin smaller.

Occurrence. Lower *Inoceramus* Bed at Bagh.

*After Nagao & Matsumoto (1939, p. 256, text fig. 1)

Inoceramus (*Inoceramus*) *malwaensis* sp. nov.

(Pl. 2, Fig. 3)

Material. Four specimens.

Holotype No. Bc. 22.

Description. Shell is inequivalve, inequilateral and rather tall, produced posteriorly into an ear with a concave surface and anteriorly curved umbones. The surface is covered with concentric folds more prominent than intervening concavities. The folds terminate abruptly on the posterior ear margin, and have their ventral slope steeper than dorsal. They are broader in the central and anterior regions than in the posterior part of the shell.

Remarks. Appreciably less convex and probably broader shell; ornamentation much weaker and more oblique posteriorly to the maximum convexity of the shell separate the present species from *I. geinitzianus* Stol. (Stoliczka 1871, p. 407, pl. 27, Figs. 4 & 5; Geinitz 1872-75, p. 9 & 1873, p. 9) from Utatur and Trichinopoly groups of South India and Upper Greensand of Kieslingswald in Glatzischen which it resembles in a general way.

I. lamarcki websteri Mant., from Upper Chalk (Woods 1911, p. 318, pl. 53, Figs. 1 & 2) like the present species has fairly similar well developed, broad but indistinctly delineated ear, but the English species is shorter and more tumid, and its concentric folds not so oblique as in our specimens. With these differences the present species on the whole approaches nearer to *I. lamarcki webstari* than to *I. geinitzianus.*

Occurrence. Lower *Inoceramus* Bed at Bagh and Rampura; Upper *Inoceramus* Bed and Deola-Chirakhan Marl at Sitapuri.

Inoceramus (*Inoceramus*) *duplex* sp. nov.

(Pl. 1, Figs. 10, 11)

Material. One specimen.

Holotype. No. Irl. 10.

Description. Shell is inequivalve, inequilateral with height and length practically equal, and postero-ventrally drawn out obliquely. Anterior margin is distinctly concave and shorter than broadly circular posterior side. The ear is small and indistinct. Angle between the hinge margin and anterior side is acute. Concentric ridges finer and closely spaced up to 1/3rd of the surface from umbones become stronger and wider spaced in the later part of the shell. Concentric ridges have their dorsal slope less steep than the ventral slope.

Remarks. By its short and slightly concave anterior margin, the left valve bigger and flatter than the right one; the nature and course of the ribs similar the present species is much like *I. yabei* Nagao & Matsumoto (Nagao & Matsumoto 1939, pl. 34, Figs. 5-7; 1490, p. 1, pl. 1, Figs. 1-6; Pl. 2, Fig. 8?) a species from Cenomanian and Turonian of Japan. The only difference and very striking one between the two species is that the concentric ridges on the 1/3 surface from the umbones are very fine and close set in our species.

Occurrence. Lower *Inoceramus* Bed at Padlya.

Inoceramus (*Inoceramus*) *anglicus rampuraensis* subsp. nov.

(Pl. 1, Figs. 8, 9)

Material. Two specimens.

Holotype. No. Ram. 7/69.

Description. Shell is taller than long, more oval than pear shaped with right valve much flattened. The ear is rather small. Ridge running from dorsal to the postero-ventral side is more prominent on the left valve.

The surface is ornamented with strong concentric folds having narrowly rounded crests and often tending to split on the lateral regions. The depressions between the folds are slightly but distinctly narrower than the folds.

Remarks. Like *I. duplicatus* Anderson (Anderson 1958, p. 100, pl. 17, Figs. 3 & 4) from the Middle Turonian of Oregon our species shows splitting of the concentric folds, but the American species is distinctly much taller and has a straight anterior side.

Our specimens, however, show a closer resemblance to *I. anglicus* Woods with which it is associated here (Woods 1911, p. 264, pl. 45, Figs. 8-10; Text Fig. 29; and 1912, p. 5, Figs. 28, 29, 56 & 57). The more observable differences are that the present form is slightly broader and less tumid. These two features are complimentary. Its maximum tumidness is a little more posteriorly situated and therefore, the turning point in the curvature of the concentric folds also appears correspondingly shifted. The concentric folds tend to split more often into two subequal folds but rest of the pattern of all the folds along with the fine ridges on their slopes and the course followed by them show an essential gradation between *I. anglicus* and the present specimens. Hence, they are reported as a subspecies of *I. anglicus.*

Occurrence. Base of the Nodular Limestone at Rampura.

Inocarmus (*Inocarmus*) *crippsi sub-ovatus* subsp. nov.

(Pl. 2, Fig. 4)

Material. Four specimens.

Holotype No. Ch. 37/69.

Description. It is a species with a long hinge margin and quadrate to subovate outline. The surface carries a few prominent folds and depressions covered with fine concentric striae; each fold splits into two sub equal subsidiary crests over most of the median region, and thus appearing as independent folds.

Dimensions. Angle $\alpha = 112°$, $\beta = 84°$, $\sigma = 90°$.

Remarks. The general shape of the shell, the ornamentation pattern and the feeble but easily observable change in the convexity of the concentric folds down the median region show a gradation in the direction *I. crippsi—I. crippsi ovatus* (*vide Infra*)—*I. crippsi subovatus*. This leads us to regard the specimens described here (and also those described next) only a subspecies of *I. crippsi* Mant. Thus these three forms constitute a closely related group. Moreover, their stratigraphic positions in the present series of strata also agree with the direction of variation in their morphological features; the present subspecies comes from the Deola-Chirakhan Marl and the Upper Coralline Limestone, i.e. horizon stratigraphically higher than that of *I. crippsi* and *I. crippsi ovatus* (*vide infra.*).

It must, however, be mentioned that the present form bears close resemblance also with *I. amakuensis* Nagao & Matsumoto from Coniacian and Santonian of Japan (Nagao & Matsumoto 1940, p. 13, pl. 3, Fig. 6; pl. 4, Figs. 1, 3 & 4; pl. 5, Fig. 1) and *I. circularis* Schlüter (Andert 1929, p. 52, pl. 4, fig. 23) particularly with the latter. But considering the morphological gradations as explained above and their occurring in successive horizons in the present area we regard the specimens as a subspecies of *crippsi* rather than any way place it close to *I. amakuensis* and *I. circularis* which are themselves considered by Nagao & Matsumoto as being related to *I. crippsi* Mant.

Occurrence. Deola-Chirakhan Marl and Upper Coralline Limestone at Chirakhan.

Inoceramus(*Inoceramus*) *crippsi ovatus* subsp. nov.

(Pl. 2, Fig. 1)

Material. One specimen.

Holotype No. Ram. 17.

Description. Shell is ovate feebly drawn out postero-ventrally, a little to the posterior of the median region with fairly long and straight dorsal margin. Anterior margin is broadly convex; ventral margin merging into it and the posterior margin smoothly.

Ornamentation consists of concentric folds occurring as subequal folds due to splitting of the major folds in the median region. Folds and intervening depressions carry fine concentric striae.

Remarks. As compared to *I. crippsi* Mant., a species having wide geological and geographical distribution (Woods 1911, p. 273, pl. 48, figs. 2-3, text-figs. 33-35; Leonard 1897, p. 49, text-fig. 6; Heinz 1928, p. 57, pl. 6, fig. 1) present specimen differs in having much more elongate form and smaller angle between the hinge and the anterior margin.

However, as discussed under *I. crippsi subovatus* subsp. nov. (*vide supra*), the present specimen can be taken as a subspecies of *I. crippsi* Mant.

Occurrence. Lower *Inoceramus* Bed at Rampura.

Inoceramus (*Cremnoceramus*) *inconstans impressus* subsp. nov.

(Pl. 1, Figs. 3 & 4)

Material. One specimen, only LV.

Holotype No. BW. 21/69.

Description. It is highly convex shell with umbo prominent and anteriorly curved. The anterior side is impressed forming a cordate area delimited by a ridge running from umbones to the antero-ventral margin. The zone of maximum convexity gives the appearance of a ridge running medianly from umbo to ventral margin. Ornament consists of low concentric folds carrying 6-8 fine ribs.

Remarks. The present form is very similar to *I.* (*C.*) *inconstans striatus* Mant. (Sowerby, 1828, p. 160, pl. 582, fig. 2; Woods 1912, p. 292, pl. 51, fig. 5; pl. 52, fig. 1; and 1912b, p. 16, figs. 84 and 85) from the zone of *Holaster planus* and *Micraster coranguinum* in its general shape and ornamentation; but difference lies in the present form having a well impressed anterior side, the umbo more strongly curved anteriorly and its concentric folds much less raised.

Occurrence. Base of the Nodular Limestone at Bowarla.

Inoceramus (*Mytiloides*) *labiatus chirakhanensis* subsp. nov.

(Pl. 2, Fig. 2)

Material. One specimen.

Holotype. No. CH 18/69.

Description. It is a very tall, equivalve, elongately oval shell with umbones subcentral, prominent anda nteriorly curved and a small ear. The anterior side is rather straight and shorter than the broadly convex posterior. Ventral side is highly convex. Maximum tumidity runs down the median axis at about 1/4th the height from the dorsal side. Ornamentation consists of strong concentric folds drawn out postero-ventrally, in the median region; folds have rounded crests, dorsal slope steeper than the ventral slope, and are narrower than the intervening depressions. Fine concentric striae cover the folds and depressions but their number could not be determined in our specimen.

Remarks. As judged from the ornamentation and outline our specimen closely resembles *I.* (*M.*) *labiatus* Schloth. *opalensis* Bäse and probably has close similarity also to form *Glongata* of Seitz (Petrascheck 1903, p. 159, text-fig. 1; Bäse 1913, p. 25, pl. 1, fig. 14; pl. 2, figs. 1, 2 & 5; pl. 3, fig. 2; Arkhanguelsky 1916, p. 16, pl. 2, fig. 2; Bäse 1923, p. 184, pl. 12, fig. 5; Heinz 1928b, p. 63, pl. 4, fig. 5; Seitz 1934, p. 458, Text fig. 14, 15 plates in the available volume are totally damaged and could not be examined), coming from Turonian of Mexico, Brazil, Turkestan, and Germany. But since these regions are widely apart from the Narmada Valley, we prefer to assign present material to a new subspecies.

Occurrence. Upper *Inoceramus* Bed 0.5 km south of Chirakhan in a well-cutting.

Inoceramus (*? Sphenoceramus*) *agharkarianus* sp. nov.

(Pl. 2, Fig. 5)

Material. One specimen.

Holotype No. CH. 27/69.

Description. The shell is moderately tumid, labiate, distinctly taller than long with maximum tumidity roughly at the middle. A linear, low but distinctly observable depression is situated along the posterior side of a ridge running down medianly.

Shell is ornamented with concentric folds having ventral slopes steeper than the dorsal. Each ridge and intervening depression carry 4-6 very fine ridges. Concentric folds and the finer ridges on them have broad low and blunt tubercles apparently falling in radial alignment, but no radial ribs or ridges are distinctly observable.

Remarks. Present specimen resembles very closely *I. cordissoides* Goldf. (Woods 1912, p. 300, text-figs. 57-58; 1912b, p. 18, fig. 92) from Senonian of Germany and Upper Chalk of England (probably zone of *Actinocamax quadratus*) in outlines, characteristic tuberculate nature of the concentric ornament, sudden deflection of concentric ridges towards the wing and the depressed area particularly of the median region. The point of obvious difference is that the radial ribs so well developed in *I. cordissoides* are not developed though only indicated by the alignment of the tubercles on our specimen and hence the new name.

To the extent that the morphological features and the general aspects go, it is difficult to say on which grounds the present material can be separated from *Sphenoceramus cordissoides* (Goldf.) except that the latter species occurs at a horizon higher than what we are led to consider appropriate for the Bagh Beds. But considering that the stock out of which *Sphenoceramus* is supposed to have evolved i.e. *I. inconstans—I. lingua—I. lobatus—I. cordissoides* (vide Woods 1912b, p. 6) is represented in the Bagh Beds (by e.g. *inconstans* stock). This potential trend leading to *Sphenoceramus cordissoides* (Goldf.) has probably got expressed in the form of our present material, which we name as *Inoceramus* (*? Sphenoceramus*) *agharkarianus*. Such a step while trying to avoid possible confusion between these two species from too much different horizons, however, raises the question whether the genus *Sphenoceramus* has appeared in the present basin earlier than in England, Germany, etc., where it is taken as a Senonian genus (*Treatise*, vol. N, pt. 1), or that our material needs an altogether another place. Under these circumstances we record our material here as *Inoceramus* (*?Sphenoceramus*) *agharkarianus* by choosing to place the term *Sphenoceramus* within brackets preceded by a question mark. But taking the position as it is, the very close affinity (only next to identity) of our present material towards *Sphenoceramus cordissoides* cannot be ignored.

Occurrence: Upper *Inoceramus* Bed at Chirakhan.

GENERAL DISCUSSION

(I) THE LOWER AND THE UPPER *Inoceramus* BEDS

Distribution of the inoceramid species as given in Table I shows that there is only one species, viz. *Inoceramus* (*I.*) *malwaensis* sp. nov. which occurs almost throughout the Bagh succession. Of the remaining thirty three species we find that they tend to fall essentially into two distinct groups, one confined to the Nodular Limestone, and the other to the Deola-Chirakhan Marl and the Coarlline Limestones. Within these two groups major concentration of species, numerically and varietally, occurs at two horizons, first near the top of the Nodular Limestone and the second near the top of the Deola-Chirakhan Marl. A few of the species of the former group do occur in the lower and middle portions of the Nodular Limestone; similarly a few species of the other group are found in the Coralline Limestones; that they, however, do rather sporadically, and thus make the two horizons of their concentration so conspicuous that they can not be overlooked even in the field; the one near the top of the Nodular Limestone we have named Lower *Inoceramus* Bed, and it has seventeen species of inoceramids represented in it; the other one coming near the top of the Deola-Chirakhan Marl we have designated as the Upper *Inoceramus* Bed, and it has twelve species of *Inoceramus* crowded in it.

Out of the species represented in these two horizons while their entire lists (for which vide Table 2) need not be repeated here, only those species which are particularly abundant in them and thus may be considered as constituting assemblages peculiar to them, may be cited here. Thus in the Lower *Inoceramus* Bed we have *I. (I.) lamarcki* Park., *I. (I.) concentricus* Park., *I. (I.) heinzi* Sornay, *I. (Cremnoceramus) inconstans* Woods, *I. (C.) inconstans striatus* Mant., ; *I. (C.) inconstans schloenbachi* Fiege and in the Upper *Inoceramus* Bed the species which need being mentioned in this context are: *I. (Mytiloides) labiatus* Schloth., *I. (M.) labiatus chirakhanensis* subsp. nov., *I. (I.) unguliformis* sp. nov., and *I. (I.)* sp. cf. *I. mantelli angustus* Seitz.

Table 1

Table showing the affinities of *Inoceramus* species at different levels

Lithological Units of the Bagh Beds	Range as indicated by *Inoceramus* species
Upper Coralline Limestone ..	Cenomanian to Campanian
Upper Inoceramus Bed ..	Albian to Turonian
Deola-Chirakhan Marl ..	Albian to Campanian
Lower Coralline Limestone ..	Presence of *Inoceramus* species unnoticed.
Lower Inoceramus Bed ..	Albian to Campanian
Middle portion of Nodular Limestone.	Albian to Senonian
Base of Nodular Limestone ..	Albian to Senonian
Nimar Sandstone	So far no species of *Inoceramus* found.

Besides *I. (I.) malwaensis* sp. nov. which as mentioned earlier, is met with in almost the entire Bagh succession, *I. (C.) inconstans sarumaensis* Woods, is the only other form which is found occurring in both the *Inoceramus* Beds.

A general observation that could be made about the inoceramids in these two beds, is that their shells in the Lower *Inoceramus* Bed are on the whole smaller in size, have a larger proportion of them in fragmentary condition and also of their valves displaced or rotated relatively to one another, as compared to what is encountered in the Upper *Inoceramus* Bed.

Such high concentration of the inoceramid population in these two beds shows that during their deposition bottom conditions, such as temperature and the abundance of nutrition, were particularly favourable, especially so at the time of deposition of the Upper *Inoceramus* Bed, where the species grew larger shells. The large proportion of broken and displaced valves in the Lower *Inoceramus* Bed was perhaps due to waters being more disturbed when it was being deposited.

To consider the other bivalves (Chiplonkar & Badve, 1972b) occurring in these two beds, we find that while a few species may be found occurring on one and not in the other bed, in general mytilid and modiolid species as also the species of *Protocardia* are by and large common to all of them. But the behaviour of the species of *Pholadomya*, *Plicatula* and *Neithea* is different. Thus *Pholadomya* has all its species (except one) in the upper part of the Nodular Limestone, associated with the Lower *Inoceramus* Bed. All the species of *Plicatula* and the species of *Neithea* occur mostly in the Deola-Chirakhan Marl and in the Coralline Limestone; but the Coralline Limestone rarely yields collectable loose specimens of bivalves; and thus species of these tw genera could be considered to be derived mostly from the Deola-Chirakhan Marl, associated with the Upper *Inoceramus* Bed. Therefore, where local conditions may not reveal easily the presence of these *Inoceramus* Beds their horizons could be indirectly located with the help of these bivalve species as associates of the respective inoceramid assemblages.

Thus these two *Inoceramus* Beds having essentially the same lithic nature viz. marly limestone and much of their non-inoceramid bivalve fauna in general similar and similarly abundant, occur as two distinct horizons stratigraphically well separated from one another and having their own assemblages of species of Inoceramidae and *Plicatula*, *Neithea* and *Pholadomya*. This is an aspect of them which deserves being interpreted on the basis of a detailed analysis of the entire Bagh fauna *vis-a-vis* the course of sedimentation.

(II) Age:

The accompanying Table 2 gives the vertical distribution of the inoceramid species in the Bagh Beds, their affinities (or of the species related to them) and their geological horizons as known in other regions. In Table I is shown the summarized geological time range as

TABLE 2

Table showing the vertical distribution and affinity-relations of the bivalves—Inoceramidae from the Bagh Beds

Serial number	Species from the Bagh Beds	Related with geological horizon	Nodular Limestone			Lower Coralline Limestone	Deola Chirakhan Marl		Upper Coralline Limestone
			Basal portion	Middle portion	Upper portion (*Lower Ino. Bed*).		Lower portion	Upper portion (*Upper Ino.* Bed.)	
1	2	3	4	5	6	7	8	9	10
1	*Inoceramus* (*I.*) *pronus* sp. nov.	*I. seitzi* Andert; Upper Turonian of Germany.	×		..	..	..	..	..
2	*Inoceramus* (*I.*) *unguliformis* sp. nov.	*I. aduncus* Anderson; Turonian of Oregon and California, U.S.A.	..	..	..	..	×	×	×
3	*Inoceramus* (*I.*) *subtrigonoides* sp. nov.	*I. teshioensis* Nagao & Matsumoto; Turonian of Japan.	..	..	×	..	..	..	..
4	*Inoceramus* (*I.*) *malwaensis* sp. nov.	*I.* (*I.*.) *lamarcki* Park.; Turonian of England, Germany, France.	..	×	×	..	×	×	..
		I. (*I.*) *geinitzianus* Stol.; Utatur and Trichinopoly groups of South Indian Cretaceous.							
5	*Inoceramus* (*I.*) *duplex* sp. nov.	*I. yabei* Nagao & Matsumoto; Cenoomanian-Turonian of Japan.	..	..	×	..	..	..	..
7	*Inoceramus* Woods.	(*I.*) *anglicus I. anglicus* Woods; Upper Greensand and Gault of England.	×	×	..	..	..	..	..
	Inoceramus (*I.*) *anglicus* Woods *rampuraensis* subsp. nov.	*I. anglicus* Woods; Upper Greensand and Gault of England.	×	..	..	..	..	..	..
8	*Inoceramus* (*I.*) *pictus* Sow	*I. pictus* Sow.; from *Schloenbachia varians* to *Holaster subglobosus* zones in England and Upper Cenomanian-Turoniann of Europe, Africa, South America, North America Australia.	..	×	×	..	..	..	..
9	*Inoceramus* (*I.*) *costellatus* Woods.	*I. costellatus* Woods; lower portion of *Holaster planus* zone of England and Upper Turonian of Germany.	..	×	..	..	..	..	..
10	*Inoceramus* (*I.*) *crippsi* Mant.	*I. crippsi* Mant.; widely occurring from Cenomanian to Campanian in North America, South America, England, Europe, North Africa, Japan (?)	..	..	×	..	..	..	..
11	*Inoceramus* (*I.*) *crippsi* Mant. *subovatus* subsp. nov.	Ditto. ..	..	..	..	..	..	×	×

1	2	3	4	5	6	7	8	9	10
12	*Inoceramus* (*I.*) *crippsi* Mant. *ovatus* subsp. nov.	*I. crippsi* Mant.; widely occurring from Cenomanian to Campanian in North America, South America, England, Europe, North Africa, South India, Japan (?)	..	..	×	..	..	..	..
13	*Inoceramus* (*I.*) *latus* Mant.	*I. latus* Mant.; Turonian of Germany.	..	×	..	..	..	..	..
14	*Inoceramus* (*I.*) *lamarcki* Park.	*I. lamarcki* Park.; from *Rhynconella cuvieri* to *Micraster corangulinum* Zones in England, Turonian of France and Kreidemergel of Germany (Particularly from Turonian).	..	×	×	..	..	..	..
15	*Inoceramus* (*I*) *lamarcki* Park. *cuvieri* Sow.	*I. lamarcki* var. *cuvieri* Sow. zone of *Terebratulina lata* in England and Upper Turonian of Germany.	..	..	..	..	..	×	×
16	*Inoceramus* (*I.*) *lamarcki* var. *indicus* Chipl.	*I. lamarcki* Park.; Turonian of England, France and Germany.	..	..	×	..	×	×	..
17	*Inoceramus* (*I.*) sp. cf. *Inoceramus* (*I.*) *mantelli* Merci var. *angustus* Seitz.	*I. mantelli* Merci var. *angustus* Seitz from Lower and Middle Coniacian of Germany.	..	..	..	..	..	×	×
18	*Inoceramus* (*I.*) sp. cf. *Inoceramus* (*I.*) *tenuis* Mant.	*I. tenuis* Mant.; from Upper Greensand and Chalk Marl of England and Upper Turonian of South America (Peru).	..	..	×	..	..	..	..
19	*Inoceramus* (*I.*) *Heinzi* Sornay.	*I. heinzi* Sornay; Middle and Upper Cenomanian and (?) Lower Turonian of Southwest region of Madagascar.	..	..	×	..	..	..	..
20	*Inoceramus* (*I.*) *patootensis* Lor.	*I. patootensis* Low.; Lower and Middle Senonian of Europe, North America and Greenland.	..	×	×	..	..	..	..
21	*Inoceramus* (*I.*) *concentricus* Park.	*I. oncentricus* Park.; Upper Greensand of England, Gault of Germany, and Chalk of France; Cenomanian of Japan.	..	×	×	..	..	..	..
22	*Inoceramus* (*I.*) sp. indet.	*I. subundatus* Meek; from Lower Coniacian of Oregon, U.S.A.	..	..	..	..	..	×	..
23	*Inoceramus* (*Birostrina*) *sub sulcatus* Wilt.	*I.* (*Birost.*) *subsulcatus* Wilt.; Gault of England.	..	×	×	..	..	..	..

1	2	3	4	5	6	7	8	9	10
24	*Inoceramus* (*Cataceramus*) *goldfussianus* d'Orb.	*I.* (*C.*) *goldfussianus* d'Orb. Senonian of England, France, Germany and Japan.	..	..	..	..	..	×	×
25	*Inoceramus* (*Cremnoceramus*) *inconstans* Woods *impressus* subsp. nov.	*I.* (*Cremno.*) *inconstans* Woods.; *striatus* Mant. from *Holaster planus* to *Micraster coranguinum* Zone of England.	×	..	..	..	..	..	..
26	*Inoceramus* (*Cremno.*) *inconstans sarumensis* Woods	*I.* (*Cremno.*) *inconstans* Woods, *sarumensis* Woods from *Actinocamax quadratus* zone of Upper Chalk of England.	..	..	×	..	..	×	..
27	*Inoceramus* (*Cremno.*) *inconstans striatus* Mant.	*I.* (*Cremno.*) *inconstans striatus* Mant.; from *Micraster corguinum* zone of Upper Chalk of England.	..	..	×	..	..	..	..
28	*Inoceramus* (*Cremno.*) *inconstans Schloenbachi* Fiege.	*I.* (*Cremno.*) *inconstans* Woods *Schloenbachi* Fiege; from Upper Turonian of Germany.	..	..	×	..	..	..	..
29	*Inoceramus* (*Cremno.*) *niger* (Heinz).	*I.* (*Cremno.*) *niger* (Heinz) from Coniacian of Camerroons, Angola, Nigeria and perhaps Campanian of same regions.	..	..	..	..	..	×	..
30	*Inoceramus* (*Mytiloides*) *labiatus* Schloth.	*I.* (*M.*) *labiatus* Schloth. world wide distribution, particularly in Lower Turonian.	..	..	..	...	..	..	×
31	*Inoceramus* (*Myti.*) *labiatus chirakhanensis* subsp. nov.	*I.* (*M.*) *labiatus* Schloth. *opalensis* Boese; from Turonian of Mexico, Brazil, Turkasthan and Germany.	..	..	..	..	..	×	..
32	*Inoceramus* (*Myti.*) *labiatus* Schloth. *antsaronaensis* Sornay.	*I.* (*M.*) *labiatus* Schloth. *antsaronensis* Sornay; Lower Turonian of Madagascar.	..	..	×	..	..	..	..
33	*Inoceramus* (*Myti.*) *labiaatus* Schloth *subhercynica* Seitz.	*I.* (*M.*) *labiatus* Schloth.. *subhercynica* Seitz. ; from Turonian of Mexico and Cenomanian Turonian of Germany.	..	..	..	..	×	..	..
34	*Inocerramus* (*? Sphenoceramus*) *agharkarianus* sp. nov.	*Sphenoceramus cordisoides* (Gold.) from Senonian of England and Germany.	..	..	..	..	..	×	..

indicated by these species for the different constituent members of the Bagh Beds.

Of the eleven taxa described here new, *I.* (*I.*) *anglicus rampuraensis* subsp. nov. is the lone form showing Lower Cretaceous affinities, being related to *I. anglicus* Woods from the Gault and Upper Greensand of England. Then, we have here *I.* (*C.*) *inconstans* Park. *impressus* subsp. nov. and *I.* (*? S.*) *agharkarianus* sp. nov. with affinities towards species in the Senonian of England and Germany, respectively. The two subspecies of *I.* (*I.*) *crippsi* Mant., viz. *ovatus* subsp. nov. and *subovatus* subsp. nov., show Cenomanian to Campanian range, like the widely occurring species *I.* (*I.*) *crippsi* Mant. to which they are related, but being here associated with many species of Turonian affinities these also can be considered as representing Turonian as the main element.

The remaining six of the new species have distinct Turonian alliance. Thus, *I.* (*I.*) *pronus* sp. nov. has its nearest ally *I.* (*I.*) *seitzi* Andert from the Upper Turonian of Germany, *I.* (*I.*) *unguliformis* sp. nov. shows close affinity towards *I.* (*I.*) *aduncus* Anderson from the Turonian of Oregon and California. *I.* (*I.*) *duplex* sp. nov. and *I.* (*I.*) *subtrigonoides* sp. nov. are respectively related to *I. yabei* Nag. & Mat. and *I. teshioensis* Nag. & Mat. from the Turonian of Japan. Being closely comparable to *I. geinitzianus* Stol. from the Utatur and Trichinopoly groups of South India and perhaps more so to *I.* (*I.*) *lamarcki* Park. *websteri* Mant. from the Upper Chalk of England. *I.* (*I.*) *malwaensis* sp. nov. again points to Turonian affinities. *I.* (*M.*) *labiatus* Schlath *chirakhanensis* subsp. nov. is related to *I.* (*M.*) *labiatus opalensis* Boese from the Turonian of Mexico, Brazil, Turkastan and Germany.

Then we have in these beds 23 inoceramid species which are known to occur in regions outside the Narmada Valley and where their geological horizons are already known. Without going into lengthy and detailed discussions of the occurrences of each of them, we may briefly make here reference, in particular, to those species only which have an important bearing on the question of geological age of the present inoceramid fauna.

Among such species, we have *I.* (*M.*) *labiatus* Schl. from the Turonian horizon and having a very wide geographic distribution. Then, *I.* (*I.*) *lamarcki* Park., *I.* (*I.*) *lamarcki couveri* Sow., *I.* (*I.*) *latus* Mant., *I.* (*I.*) *costellatus* Woods and *I.* (*C.*) *inconstans schloenbachi* Fiege are recorded from the Turonian of several European countries such as France, Germany, England, etc. *I.* (*M.*) *labiatus antsorenesis* Sorney is reported from the Turonian of Madagascar. *I.* (*M.*) *labiatus subhercynica* Seitz is known to occur in the Turonian of Germany and Mexico.

Species like *I.* (*I.*) *pictus* Sow., having a very wide geographic distribution and *I.* (*I.*) *heinzi* Sornay from Madagascar show conspicuous Cenomanian aspect coupled with the Turonian; while, *I.* (*I.*) *crippsi* Mant. is an important species having a wide geographic distribution and ranging from Cenomanian to Campanian.

Then species such as *I.* (*Birostrina*) *subsulcatus* Wilt. from the Gault of England, I. (*I.*) *concentricus* Park. from the Cenomanian of Japan, Gault of Germany and England and *I.* (*I.*) *anglicus* Woods from the Greensand of England show conspicuous presence of Cenomanian element in the Bagh inoceramids.

From the foregoing discussion, it is clear that though a few species with Gault and Cenomanian and Senonian affinities are present in the Bagh Beds, the aspect which they have most predominant and persistent at all levels within the Bagh Beds in Turonian. The age which can, therefore, be considered appropriate for this inoceramid fauna is Cenomanian-Turonian, the former being no doubt subordinate but noticeable specially in the lower part of the Nodular Limestone.

This conclusion concerns the limestones and the marl from where all the inoceramids discussed here have come. The basal member of the series, the Nimar Sandstones has not yielded any inoceramids. It has, however, in its upper part, the *Astarte* Bed which has yielded (Chiplonkar & Badve, 1972b) species like *Astarte sinuicostata* Chipl. & Bad. and *A. flexicostata* Chipl. & Bad., which are allied to species from Aptian and Greensand horizons in England, France and Germany; and these species occur, though less abundantly, also in the succeeding Nodular Limestone. From the *Turritella* Bed, again associated with the upper part of the Nimar Sandstone, and in all probability at the same horizon as the *Astarte* Bed (Chiplonkar & Badve, 1972a), we have *Turritella chikliensis* Chipl. & Bad. for which *T.* (*Haustator*) *meadi* Bailey from the Campanian of Pondoland and the Maestrichtian of Cameroons is the nearest comparable species.

We may here anticipate some of the points from our forthcoming report on the Bagh oysters (Chiplonkar & Badve, 1974) to the extent that they are again relevant to the question of the relation between the Nimar Sandstone and the succeeding Nodular Limestone. In the upper part of the Nimar Sandstone, we have an *Oyster* Bed; it is at a horizon a little lower than even the *Astarte* Bed and the *Turritella* Bed (Chiplonkar & Badve, 1972a). Majority of the oyster species in this bed have mainly Cenomanian affinities, their Turonian aspect being quite subordinate; their Turonian aspect, however, becomes relatively more conspicuous at higher levels in the series. Thus the upper part of the Nimar Sandstone containing these three beds, viz., the *Oyster* Bed, the *Astarte* Bed and the *Turritella* Bed, is palaeontologically in continuity with the succeeding Nodular Limestone.

So taking together all the bivalves from the Bagh Beds and treating them as a fauna as a whole, they are of Cenomanian-Turonian age. The Inoceramidae not being represented in the Nimar Sandstone, but only from above it onwards, have naturally a slightly newer appearance to begin with. Therefore, their age with Cenomanian aspect subordinate to the Turonian, as discussed above, is not in conflict with the conclusions arrived at with respect to the affinities of the other Bagh bivalves (Chiplonkar & Badve, 1972b).

(III) Faunal affinities:

To consider the more salient features (vide Table 1) of the affinities of the species described here, we find that *Inoceramus (I.) anglicus rampuraensis* subsp. nov., *I. (I.) pronus* sp. nov., *I. (I.) malwaensis* sp. nov., *I. (I.) crippsi subovatus* subsp. nov., *I. (I.) crippsi ovatus* subsp. nov., *I. (C.) inconstans impressa* subsp. nov., *I. (? S.) agharkarianus* sp. nov. and *I. (M.) labiatus chirakhanensis* subsp. nov. have their affinities to species recordea from England, Germany, Turkastan etc.; they thus belong to the North African-European palaeo-zoo-geographic region.

Again, without entering into detailed statements about the other twenty three species already known from other regions (vide Table 2) and now found occurring in the Bagh Beus of the Narbada Valley, it is clear that taken together with the new species referred to above, these inoceramids of the Bagh basin belong to the Mediterranean paleozoogeographic province.

Presence in the Bagh Beds of species such as *I. (C.) goldfussianus* d'Orb., *I. (Myti.) labiatus* Schl., *I. (I.) pictus* Sow. and *I. (C.) inconstans* Park. which occur also in Trichinopoly Cretaceous, cannot be considered to vitiate the above conclusion, because these species occur widely distributed elsewhere also and thus are not typically South Indian elements. The species *I. (M.) labiatus antsaronensis* Sornay and *I. (I.) heinzi* Sornay cannot be altogether unexpectea to occur in the Narmada Valley; because we know that sea was in existence in late Lower Cretaceous times extending from Cutch to Madagascar, South Africa and thence to east coast of South India; and with the new set up which came in close upon this, the transgressive waters going eastwards into the Narmaaa Valley could have carried there some of the elements which also went southwards towards Madagascar and South Africa and to Trichinopoly district when the transgression affected that region. It would, therefore, not mean invasion by South Indian elements into the Narmada Valley.

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REFERENCES

Anderson, F. M., 1958. Upper Cretaceous of the Pacific Coast. *Mem. Geol. Soc. Amer.* **71**: 281 p., Baltimore.

Andert, H., 1928-1934. Die Kreideablangerungen zwischen Elbe und Jeschken (Teil 3). *Abh. d. preuss. geol. Landesamt* N. F. H. **159**: 477 p.

Arkhanguelsky, D. A., 1916. Les mollusques du Cretace superieur du Turkestan. *Mem. Com. Geol.* N. S. **152**: 56 p.

Boese, E., 1913 Monographia geologica & palaeontologica del cerro de muleros. *Bol. Inst. Geol. Mexico.* **25**: 84-139.

Boese, E., 1923. Algunas faunas Cretacicas de Zacatecas, Durango Y Guerrero. *Bol. Inst. Geol. Mexico,* **42**: 219 p.

Bose, P. N., 1884. Geology of the Lower Narbada Valley between Nimawar and Kawant. *Mem. Geol. Surv. Ind.* **21**: 72 p.

Chiplonkar, G. W., 1939. Lamellibranchs from the Bagh Beds. *Proc. Ind. Acad. Sc. Ser. B.* **10**: 255-274.

Chiplonkar, B. W. & Badve, R. M., 1972a. Newer Observations on the Stratigraphy of the Bagh Beds. *Jour. Geol. Soc. Ind.* **13**: 92-95.

Chiplonkar, G. W., & Badve, R. M., 1972b. Palaeontology of the Bagh Beds, Part I. Bivalvia (excluding Inoceramidae and & ostreidae). *J. Pal. Soc. Ind.*, **17**: (In Press).

Chiplonkar, G. W., & Badve, R. M., 1974. Palaeontology of the Bagh Beds, Part V. Bivalvia Ostreidae. *J. Pal. Soc. Ind.*, Part V, *Ostreidae* (In Press).

Cox, L. R., & Newell, N. D., 1969. *Treatise on Invertebrate Paleontology*, Part N, **2**, Mollusca 6, Bivalvia, Ed. Moore, R. C., Geol. Soc. Amer. & Univ., Kansas Press.

Fiege, K., 1930. Uber die Inoceramen des oberturon mit besonderer Berücksichtigung der in Rheinland und Westfalen Vorkommende Formen. *Palaeontographica,* **73**: 31-47.

Geinitz, H. B., 1872-1875. Das Elthalgebirge in Sachsen. *Palaeontographica*, **20**, Pt. I & II.

Geinitz, H. B., 1873. Über Inoceramen der Kreiderformation. *Neues Jahrb. Min. Geol. Pal.* : 7-22.

Heinz, R., 1928a. Über die Inoceramen Newseeland und, Neu Kaledoniens und ihre Beziechungen zu dener Europas und anderer gebiete. *Mitt. Min. Geol. Staats. nst.* Inst. Hamburg. **10**: 11-30.

Heinz, R., 1928b. Über die oberkreide *Inoceramen Sud-Amerikas* und Neu Kaledoniens und ihre Bezichungen zu dener Europas underer gebiete. *Mitt. Min. Geol. Staats.* Inst. Hamburg, **10**: 42-97.

Leonhard, R., 1930. Die Kreide formation in oberschlesien. *Palaeontographica*, **44**.

NAGAO, T., & MATSUMOTO, T., 1939. A monograph of the Cretaceous *Inoceramus* of Japan. *Jour. Fac. Sci. Hakkaido Univ.* Ser. IV. Pt. 4, Nos. 3-4: 241-299.

NAGAO, T. & MATSUMOTO, T., 1940. A monograph of the Cretaceous *Inoceramus* of Japan. Ser. IV. Pt. 6: 1-64.

PETRASCHEVK, W., 1903. Über *Inoceramen* aus der Kreide Böhmens und Sachsen. *Jahrb. d. kik. geol. Reichsanst.* **53:** 153 p.

SCHLÜTER, C., 1887. *Inoceramen* und Cephalopoden der texanischen Kreide. Ober niederrhein Ger. Nat. U. Heik. Bonn in *Verh. Nat. Hist. Ver. Preuss.* Rheinland **44:** 42-45.

SEITZ, O., 1934. Die variabilität der *Inoceramus labiatus* J. Schloth. *Jahrb. Preuss. Geol.* L. A. **55:** 199-207.

SOWERBY, J. DE C., 1812-1845. *The Mineral Conchology of Great Britain,* 7 Vols. (Except Vols. 4 & 7). London, (Benjamin Meredith).

STOLICZKA, F., 1870-1871. Cretaceous fauna of Southern India. *Pal. Ind.* Ser. 6, **3**, 530 p.

WOODS, H., 1911-1912. *A monograph of the Cretaceous Lamellibranchiata of England.* Palaeontograph. Soc. Lond. **2** (Pts. 7 & 8): 261-340.

WOODS, H., 1912. Evolution of *Inoceramus* in the Cretaceous Period. *Quart. Jour. Geol. Soc. Lond.* **68.**

EXPLANATION OF PLATES

PLATE 1

1-2.	*I.* (*I.*) *pronus* sp. nov.	
1.	Side view of the left valve	× 0.74 Sp. No. Ram. 15
2.	Posterior view	× 0.74
3-4.	*I.* (*C.*) *inconstans impressus* subsp. nov.	
3.	Side view of right valve	× 0.74 Sp. No. Bw. 21/69
4.	Anterior view	× 0.74
5-6.	*I.* (*I.*) *unguliformis* sp. nov.	
5.	Posterior view	× 0.49 Sp. No. Si. 98/69
6.	Side view of right valve	× 0.49
7.	*I.* (*I.*) *subtrigonoides* sp. nov.	
	Side view of left valve	× 0.74 Sp. No. Ba. 47
8-9.	I. (*I.*) *anglicus rampurensis* subsp. nov.	
5	Side view of left valve	× 0.74 Sp. No. Ram. 7/69
9.	Side view of right valve	× 0.74
10-11.	*I.* (*I.*) *duplex* sp. nov.	
10.	Side view of right valve	× 0.74 Sp. nov. Irl. 70
11.	Side view of left valve	× 0.74

PLATE 2

1.	*I.* (*I.*) *crippsi ovatus* subsp. nov.	
	Side view of right valve	× 0.49 sp. No. Ram. 17
2.	*I.* (*M.*) *labiatus chirakhanensis* subsp. nov.	
	Side view of right valve	× 0.49 Sp. No. Ch. 18/69
3.	*I.* (*I.*) *malwaensis* sp. nov.	
	Side view of right valve	× 0.74 Sp. No. Bc. 22
4.	*I.* (*I.*) *crippsi subovatus* subsp. nov.	
	Side view of right valve	× 0.37 Sp. No. 37/69
5.	*I.* (*? Sphenoceramus*) *agharkarianus* sp. nov.	
	Side view of right valve	× 0.49 Sp. No. Ch. 27/69.