

# MIDDLE OXFORDIAN AMMONITES (PERISPHINCTINAE) FROM KACHCHH (INDIA): BIOSTRATIGRAPHIC AND PALAEOBIOGEOGRAPHIC IMPLICATIONS

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Krishna, J., Meléndez, G., Pandey, B. and Pathak, D.B. 1996. Middle Oxfordian Ammonites (Perisphinctinae) from Kachchh (India): Biostratigraphic and Palaeobiogeographic implications. [Ammonites del Oxfordiense Medio (Perisphinctinae) del Kachchh (India): Implicaciones bioestratigráficas y paleobiogeográficas]. *Revista Española de Paleontología*, N° **Extraordinario**, 140-147. ISSN 0213-6937.

## ABSTRACT

The study of a rich Middle Oxfordian ammonite succession from Kachchh (W India) supplies new evidence to support the open biogeographic connections between the Submediterranean and Indo - East-African Provinces. The studied assemblage is precisely dated as Middle to Upper Transversarium Zone, (Middle Oxfordian), on the basis of representatives of *Perisphinctes* and *Larcheria*, this finding being the first record of this West-European form from India. The dating of the assemblage is further strengthened by the occurrence of the tethyan form *Gregoryceras*.

**Keywords:** Biostratigraphy, Palaeobiogeography, Upper Jurassic, Indo - East-African Province, Submediterranean Province, Transversarium Zone.

## RESUMEN

El estudio de una sucesión rica en ammonites del Oxfordiense Medio del Kachchh (W India) añade nuevos datos en apoyo de la hipótesis de una conexión biogeográfica abierta entre las Provincias Europea e Indo-Africana oriental durante este periodo. El material estudiado ha podido ser datado con cierta precisión como parte media a superior de la Biozona Transversarium (Oxfordiense Medio) por la presencia de diversos ejemplares de *Perisphinctes* y *Larcheria*, constituyendo ésta la primera referencia de este género de afinidad europea en la India. La edad de dicho conjunto queda reforzada por la presencia del género tethysiano *Gregoryceras*.

**Palabras clave:** Bioestratigrafía, Paleobiogeografía, Jurásico Superior, Provincia Indo - Este-Africana, Provincia Submediterránea, Biozona Transversarium.

## INTRODUCTION

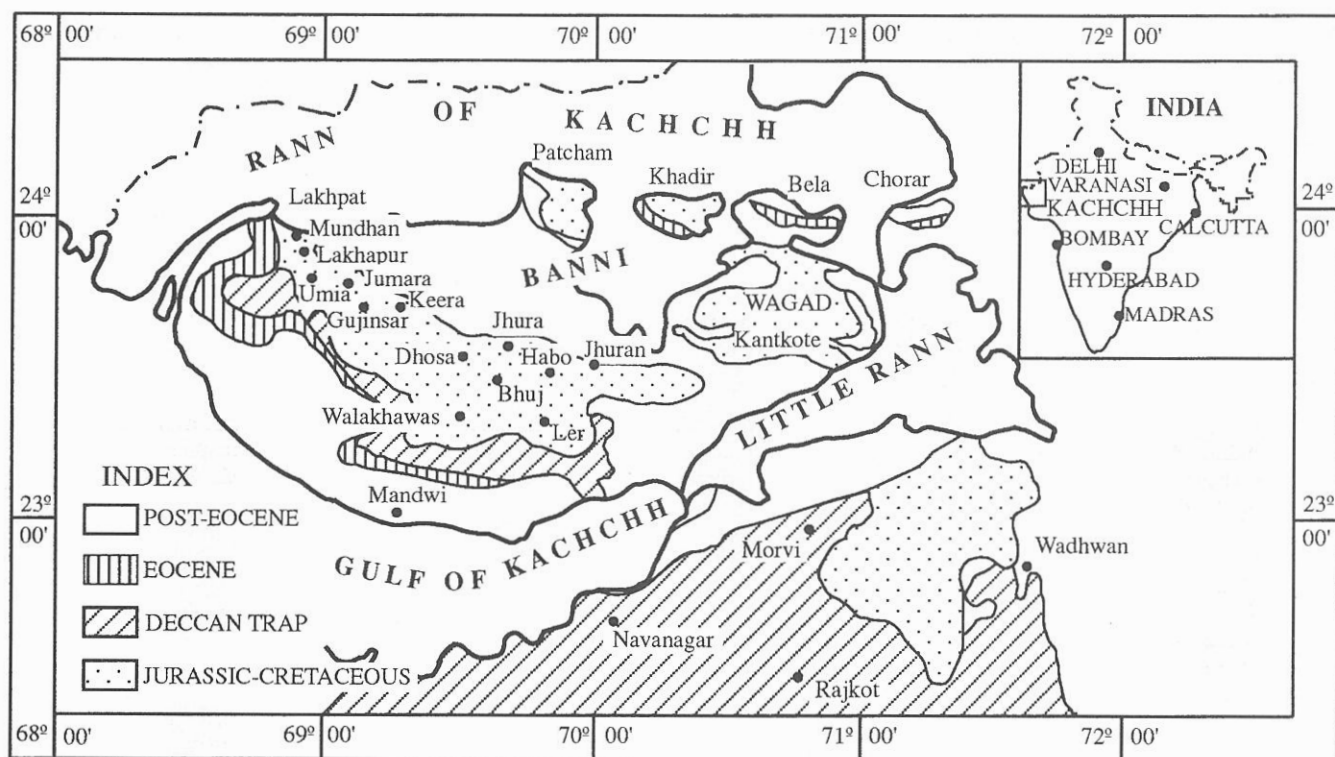
The Kachchh basin is located in the extreme West of India in the state of Gujarat (Fig. 1). The region of Wagad represents the most proximal exposed part of the Jurassic sedimentary succession of the Kachchh basin, as one of its six principal upfaulted Jurassic domes amidst extensive plainland of younger age. The other five uplifted domes are: 1: Mainland Kachchh; 2: Patcham "Island"; 3: Khadir "Island"; 4: Bela "Island" and 5: Chorar "Island".

Middle and Late Jurassic ammonite collections from Kachchh, West India, were known from the early works of Sowerby (1840), Waagen (1873-75) and Spath (1928-33). Remarkable progress has been achieved in the recent years (Krishna and Cariou, 1990, 1994; Krishna and Pathak, 1991, 1994; Callomon, 1993). The Oxfordian record, however, was mostly limited so far to the ammonite assemblage from the stratigraphically condensed Dhosa oolite unit, in the greater part of the Mainland Kachchh, spanning from Lower to earliest Middle Oxfordian. The recent finding of a relatively expanded Middle

le Oxfordian succession (Krishna *et al.* 1994) in the most proximal part of the Kachchh basin, at the locality of Wagad, East of the Mainland Kachchh, has allowed the bed-by-bed collection of thirteen stratigraphically successive ammonite assemblages. The studied ammonite collection comprises over 300 specimens belonging mostly to the geographically restricted Indo - East-African Mayaitinae and Tethyan Perisphinctinae in roughly equal proportion to the extent of 90%. The rest of the groups represented (10%), include some representatives of Euaspidoceratinae, and some few Opelellidae and Peltoceratinae, as well as some scarce, large-size representatives of Lios-traca ammonoids (Phylloceratina and Lytoceratina).

## RECENT PROGRESS IN THE JURASSIC STRATIGRAPHY OF KACHCHH

The early ammonite systematic studies by Sowerby (1840); Waagen (1873-75) and Spath (1928-33) invariably



**Figure 1.** General geological setting of the studied Kachchh area (NW India) and geographical location of the main localities mentioned in this study.

lacked precise stratigraphic information on the taxa described yet made the Kachchh jurassic succession of primary importance in global context. In the recent years a detailed recording of the sections and ammonite biochronologic studies have been undertaken under precise bed-by-bed stratigraphic collecting. This has led to a remarkable improvement in the stratigraphic resolution (Krishna and Cariou, 1990, 1994; Krishna and Pathak, 1991, 1994). More recently, detailed ammonite zonal schemes have been proposed for the Callovian, Kimmeridgian and Tithonian stages in Kachchh for the Indo - East-African Province by Krishna *et al.* (1994; Fig. 2).

## OXFORDIAN STRATIGRAPHIC DEVELOPMENT IN KACHCHH

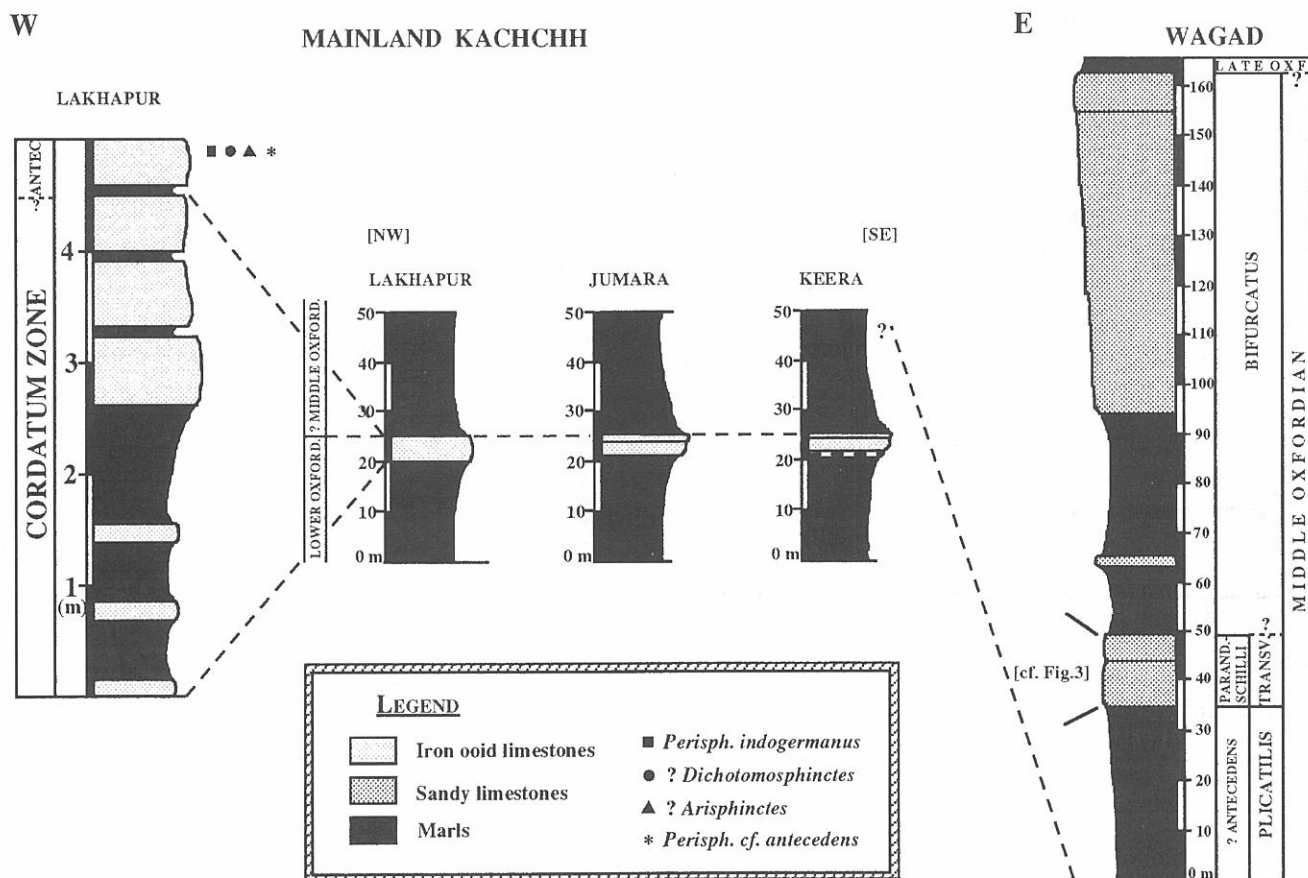
### Lithostratigraphic framework

A rich Middle Oxfordian uncondensed succession has been recently reported by Krishna *et al.* (1994) in the farthest exposed proximal part of the Kachchh Jurassic basin, at the locality of Wagad. The studied Oxfordian succession is localized at the uppermost ten meters of the Washtawa Formation (Biswas, 1977). According to this author, the Washtawa Formation consists of cross-bedded massive sandstones in the middle while its lower and upper portions are made up of alternations of thick-bedded sandstones and gypsiferous shales. This unit would broadly represent a lateral equivalent, in the proximal part of the basin, to the Chari Formation, in the widely used fourfold lithostratigraphic framework of Stolicz-

ka (in Waagen, 1873-75), applicable to the Kachchh basin (Fig. 3). The Chari Formation established in the Mainland Kachchh, with the implied type locality at Keera, is otherwise dominantly shaly in character, particularly more and more westwards towards the distal part. This unit is abundantly fossiliferous throughout. It has provided a rich Callovian to Lower Oxfordian ammonite succession in many sections across the Mainland Kachchh. These ammonite assemblages were the main subject of the classic monographs by Waagen (1873-75) and Spath (1928-33). The Washtawa Formation, in contrast, is much less fossiliferous, the ammonite record being restricted to the uppermost ten meters of the unit, whence comes a rich Middle Oxfordian ammonite association. So far no record of Callovian or Lower Oxfordian ammonites has been reported from the rest of the unit.

### Stratigraphic relations between the Dhosa oolite and the Washtawa Formation

The Oxfordian record in Kachchh has so far been limited to the so-called Dhosa Oolite, a highly condensed interval ranging in thickness from few tens of centimeters to a maximum of 6 to 7 m inclusive of a part in the underlying shales (Fig. 3). On the basis of the ammonoids enclosed, only Lower and the earliest Middle Oxfordian is found (Krishna, 1990, 1992; Krishna *et al.*, 1994). Interestingly, in the greater part of the basin the condensed Dhosa oolite is followed up by a non-depositional hiatus extending up to Lower Kimmeridgian, *Hypselocyclum* Zone (Krishna and Pathak, 1991, 1994) from the extreme distal exposed part in Lakhapur to, at least, Habo for about 100 km.



**Figure 2.** General stratigraphic correlation for the lower to middle Oxfordian rocks between the Mainland Kachchh (chari Fm) and the Wagad area (Washtawa Fm, *pars.*). The Dhosa oolite in all studied localities at Mainland Kachchh contains a rich lower Oxfordian ammonite succession which allows an excellent correlation across this basin. At Lakhapur, an uppermost association within this interval containing *Perisphinctes cf. antecedens* Salfeld and some related Perisphinctinae allows dating this upper part of the Dhosa oolite, as, roughly, Plicatilis Zone, Antecedens Subzone. At Wagad, the here studied *Transversarium* Zone ammonite succession has been recorded in a correlative, much higher levels (see Fig. 3).

Krishna *et al.* (1994) have given a succession of five ammonoid assemblages in the Dhosa oolite. The first four of these five assemblages are included in the Lower Oxfordian while the youngest has been suggested to possibly belong to the Vertebrale - Parandieri Subzone interval according to the evidence provided by the recorded taxa: *Perisphinctes indogermanus* Waagen, *Arisphinctes sp.*, *Dichotomosphinctes sp.* and *Subdiscosphinctes sp.* However, at a species level, not a single form in this assemblage has been found to show either European affinity or common features with the Middle Oxfordian of Kantkot. Yet, a few nuclei of Perisphinctinae show a style of ribbing closer to the Middle Oxfordian *Perisphinctes antecedens-buckmani* group. It cannot therefore be excluded that the lower part of the Middle Oxfordian is partly represented within the Dhosa oolite. This in turn means a slight overlap of this youngest Dhosa oolite assemblage with the oldest level of the Kantkot succession at Wagad.

Oxfordian ammonites from Kantkot and the neighbour areas were widely monographed by Waagen (1873-75) and Spath (1928-33) in their extensive works. These valuable palaeontological works lacked, however, any precise stratigraphic information about the taxa described. The sedimentary column

in this locality is about 300 m thick and the described taxa obviously may have come from different levels of this interval. Waagen assigned them to the *Transversarium* Zone. Spath ranged them from *Transversarium* to *Bimammatum* Zone. Arkell (1956) in his review assigned the Kantkot ammonites to the *Bimammatum* Zone. Biswas (1977) dated them as Argovian and correlated the Kantkot Middle Oxfordian ammonites to the Lower Oxfordian Dhosa oolite of other sections.

### Middle Oxfordian succession from Wagad

In this context the recent discovery of a non-condensed Middle Oxfordian ammonite succession at Wagad, near Kantkot has assumed considerable significance. In addition to the Middle Oxfordian ammonite succession studied here, the 200 m thick sedimentary succession recorded upwards the Middle Oxfordian beds might presumably represent the remaining stratigraphic interval until the Oxfordian-Kimmeridgian boundary. This would be evidenced by the record of scarce badly preserved Perisphinctid assemblages in a succession of five distinct levels yet without a single Mediterranean or sub-Mediterranean element for precise age determina-

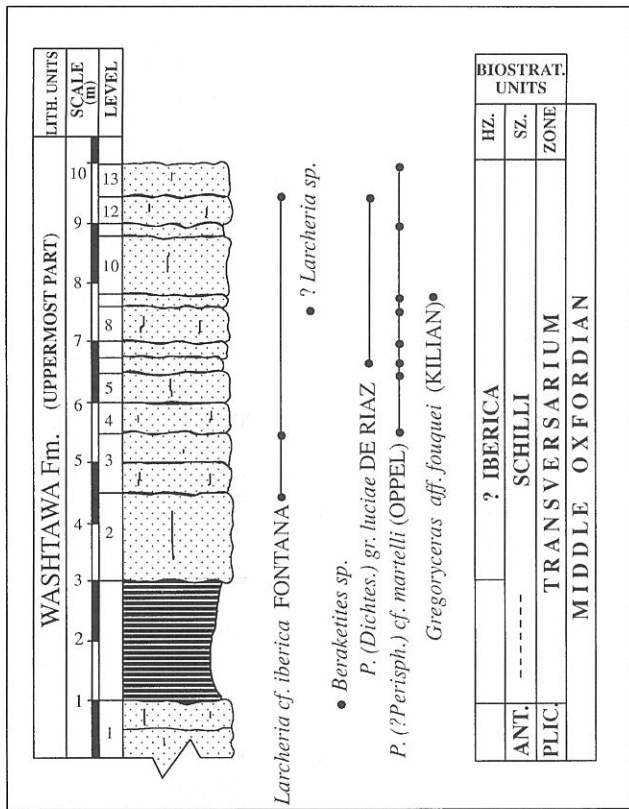


Figure 3. The stratigraphic succession of the Middle Oxfordian studied interval near Wagad (Kachchh, India).

tion, this ammonoid compositional difference between the Middle Oxfordian and these referred upper assemblages being also worth noting.

Ammonite-bearing beds are exposed along a small stream. Ammonites are collected in a well-defined thirteen-level succession of regular, brick red calcareous sandstone levels almost stacked one over the other with rare thin shale layers in between (Fig. 4). According to the primary analysis the ammonite spectrum is heavily skewed in favor of the geographically restricted Indo - East-African Mayaitinae and the Tethyan Perisphinctinae along with minor to accessory Phylloceratida, Haploceratidae, Aspidoceratidae, most specially the stratigraphically significant Peltoceratinae genus *Gregoryceras*. Representatives of Perisphinctinae include a few specimens of the north Tethyan genus *Larcheria* which mark the first stratigraphically precise occurrence of this genus on the Indo - East-African Province apart from a few references made to Collignon' (1959) madagascan forms by Tintant (1961) and Enay (1966). These occurrences are here discussed in the overall palaeontologic, biostratigraphic and palaeobiogeographic context.

The recorded Middle Oxfordian interval contains a rich ammonite assemblage including Perisphinctinae, Peltoceratinae, Aspidoceratinae, Taramelliceratinae and the geographically restricted Mayaitinae while the latter interval relatively much poorer in ammonites contains only Perisphinctids, also of rather restricted character. This compositional difference explicitly suggests restricted palaeogeographic conditions and, possibly, bathymetric decrease

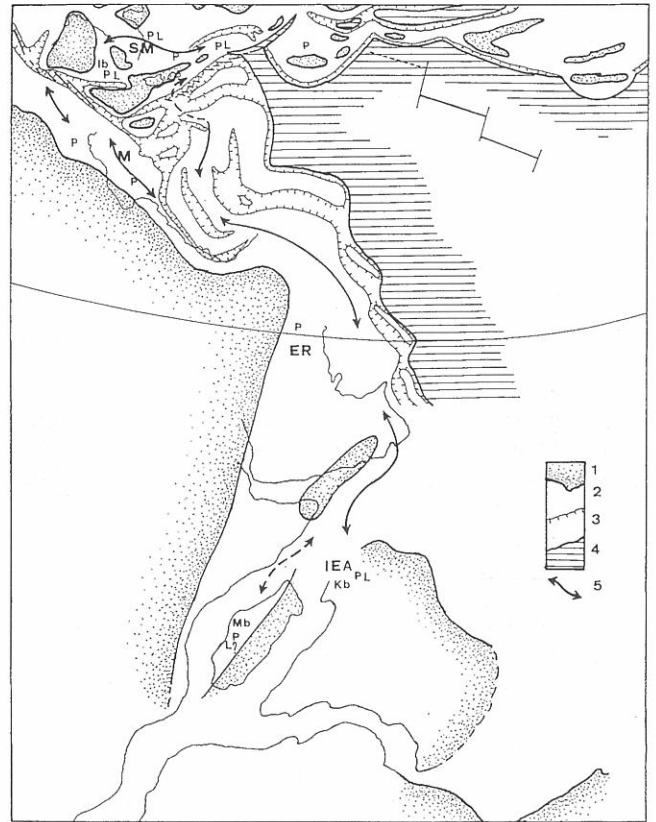


Figure 4. Paleogeographic sketch of the Tethys for Upper Jurassic times (c. Oxfordian) showing the inferred expansion of *Larcheria* between Southwest Europe and Indo-East-African Province, presumably along the borders of emerged massifs and shallow platforms of northern and, partly, southern slope of Tethys. Partly based on Cariou *et al.* (1985) and Krishna & Cariou (1990), according to the paleogeographic reconstruction in Dercourt *et al.*, (1985). 1: Emerged areas; 2: Epicontinental seas; 3: Continental margin of oceanic areas; 4: Oceanic trough areas; 5: Possible expansion ways for *Larcheria*.

after having reached a maximum in the Jurassic of Kachchh in the Middle Oxfordian Transversarium Zone. Apart from these intervals rich in ammonites, the entire 300 m thick succession in Kantkot at Wagad is devoid of ammonoids. The Middle Oxfordian interval at Kantkot is also found to be the richest in ammonites in the whole Jurassic-Cretaceous succession of Kachchh.

Concerning the correlation with the European submediterranean Middle Oxfordian a remarkable progress has been achieved in the recent years in the refinement of the ammonite biostratigraphic scale (Callomon, 1988; Meléndez, 1989; Cariou and Meléndez, 1990; Cariou *et al.*, 1991; Meléndez and Fontana, 1993). The Middle Oxfordian, above the Lower Oxfordian Cordatum Zone and below the Upper Oxfordian Bimammatum Zone includes three biozones subdivided into eight subbiozones and numerous biohorizons of which some are still of restricted geographical extent (Fig. 3; cf.



Meléndez and Fontana, 1993). The occurrence of some representatives of the genus *Larcheria* close to the *schilli* (Oppel) - *iberica* Fontana groups in the greater part of the studied ammonite succession of Kantkot has led us to tentatively assign this stratigraphic interval to the middle-upper part of the Transversarium Zone.

### Ammonite associations

The recorded stratigraphic succession forms a monotonous series of red clastic cemented calcareous sandstone beds stratified in regular decimetric, mostly 20-50 cm thick banks. The basal bank (level Nr. 1) is capped by an irregular surface and has yielded a middle-size (100 mm) adult specimen of *Beraketites* (m) sp. showing evolute serpentine coiling, coarse ribbing and thick to depressed section. This bank is followed by 1 m thick marly interval. The overlying carbonate sandstone succession has yielded a rich *Perisphinctes* assemblage and, most remarkably, some specimens of *Larcheria* and the tethyan Peltoceratinae genus *Gregoryceras*.

From level 2 comes a fragmentary specimen showing oval section, somewhat involute coiling and multidivided distant ribs with a slightly developed smooth band on the point of furcation, referable to *Larcheria* (M) close to the *schilli* (Oppel)-*iberica* Fontana group. Level 3 has yielded a similar, more complete specimen, although a septate macroconch. Above levels 4 and 5, poorer in ammonites, levels 6 to 8 contain a rich *Perisphinctinae* assemblage including both numerous finely ribbed regularly biplicate *Perisphinctes* and some evolute crassicostate, massive specimens, showing early trifurcations, difficult to place in any microconch of *Perisphinctes*. Elements of the first group are mainly incomplete microconchs and nuclei of macroconchs. They show evolute coiling and quadratic to compressed whorl section with flat sides. They appear closest to *Perisphinctes* (*Dichotomosphinctes*) of the *luciae* De Riaz group and to *Perisphinctes* (M) *kiliani* De Riaz group. This would indicate a Middle to Late Transversarium Zone age, probably, Schilli Subzone. A single adult, incomplete, septate *Perisphinctes* (M) specimen shows thick single ribs in the middle whorls and the beginning of the variocostate stage at 270 mm. diameter. Attention should be paid to some common septate macroconchs from this interval showing somewhat involute coiling, discoidal shape and ribbed, polyfurcate, non-variocostate outer whorl, difficult to match any *Perisphinctes* (M) from the Submediterranean Province. They cannot be assigned, however, to the close form *Perisphinctes leyocimon* Waagen either, since this form shows a very different multidivided, polygyrate to fasciculate ribbing. This assemblage also includes few, nearly complete, adult macroconchs of *Larcheria*. They show a somewhat evolute coiling, discoidal shape with compressed whorl section and blunt ornamentation, with distant umbilical ribs and a well-developed smooth band on the flank of the adult body chamber, at the bifurcation point. The adult size ranges from 250 to 280 mm. (cf. Meléndez and Fontana, 1992).

Also from level 8 come some few, incomplete specimens of *Gregoryceras*. Level 9 has yielded a fine complete adult, coarsely ribbed specimen of *Gregoryceras* showing tuberculate ribs, mostly looped along a periumbilical row of tubercles. This makes it closest to the species *Gregoryceras fouquei* Kilian, except for the ribs on the flank being flexuous

and retroverse and the whorl section, strongly trapezoid with concave sides. Hence it can be better interpreted as a primitive representative of this species, intermediate between *Gregoryceras transversarium* and *Gregoryceras fouquei*.

From level 10 comes a further coarsely ribbed perisphinctid showing very thick and depressed whorl section and early trifurcations. Although probably a macroconch nucleus it is morphologically closer to the typical madagascan *Perisphinctinae* (i.e. *Beraketites* and close forms) than to any submediterranean *Perisphinctes*.

Levels 11 to 13 contain again a rich, finely ribbed regularly biplicate *Perisphinctes* assemblage showing a wide variability, from involute to evolute coiling and fine biplicate and single ribs gently inclined forward on the whorl side. Yet the distinct forward sweep of secondaries on the venter, typical of such forms as *Perisphinctes* (*Dichotomosphinctes*) *wartae* Bukowski or *Perisphinctes* (*Dichotomoceras*) from top Transversarium Zone, *Rotoides* Subzone to Bifurcatus Zone is still not present. Attention should be paid to the presence in the level 12 of a further typical specimen of *Larcheria*, also a macroconch nucleus, showing evolute coiling and compressed whorl section, close to the *Larcheria iberica* Fontana group, from the Schilli Subzone.

## BIOSTRATIGRAPHIC AND PALEOBIOGEOGRAPHIC REMARKS

The first recorded level, containing *Beraketites* sp. (Collignon, 1959, Pl. LIX, fig. 276) probably corresponds to the early Middle Oxfordian. Following Enay's (1966, p.446) discussion on *Otosphinctes* and *Beraketites* this specimen shows consistent similarities with *Perisphinctes* (*Otosphinctes*) *siemiradzki* Enay and it might indicate late Plicatilis, Antecedens Subzone, to early Transversarium, Parandieri Subzone age.

Above the discontinuity the carbonate succession containing *Perisphinctes* close to the *luciae-kiliani* De Riaz groups and *Larcheria* belongs to the middle Transversarium Zone. Beds containing similar ammonite assemblages across the western Tethys are traditionally placed in the submediterranean Schilli Subzone. However, taking into account the lack so far of typical *Perisphinctes* (M) of the *martelli* Oppel-*cuneicostatus* Arkell groups among the studied assemblages and the frequent homeomorphies the representatives of *Perisphinctes* may show, it seems that such precise biostratigraphic correlation between these distant areas should not be taken without some reservation. The upper part, from levels 8 and 9 yielding some well-preserved *Gregoryceras* intermediate between *Gregoryceras transversarium* (Quenstedt) and *Gregoryceras fouquei* (Kilian) might represent the late Transversarium Zone (Fig. 3). However, further evidence is still needed from the *Perisphinctes* assemblage.

The studied ammonite associations from Kachchh support the open biogeographic connections during the Middle Oxfordian between the two margins of the Tethys (Submediterranean and Indo - East-African Province: Fig. 4). Biogeographic connections with the Submediterranean Province are stressed by the record of the West-european taxon *Larcheria*. Connections with the Mediterranean Province are underlined

by the record of the biostratigraphically significant taxon *Gregoryceras* and by the clear similarities with the Middle Oxfordian of North Algeria, at the Bechtout and Bou Redou regions (Tellian Basin), as shown by Atrops and Benest (1986, 1994). It should, however, be remarked the constant absence so far among the studied material of any representatives of the genus *Passendorferia* and related forms (subfamily Passendorferiinae Meléndez). The presence of some large-size representatives of Liostraca (Phylloceratina and Lytoceratina) in minor proportion stresses the open biogeographic connections of the studied area with the oceanic areas of Tethys which should, most probably, favor the taphonomic dispersal of drifted shells into the Kachchh basin (cfr. Fernández-López and Meléndez, 1994). The already known close biogeographical relations with Madagascar, based on the common presence of Mayaitinae, are further strengthened by the record of the Madagascan taxon *Beraketites*.

## CONCLUSIONS

Unlike the western part, Mainland Kachchh, in the Kachchh Basin the eastern, internal part of the basin at the Wagad region during the Middle Oxfordian was an open, sandy carbonate platform. Beyond the development of biogeographically restricted, endemic ammonite groups biogeographic connections with western Tethys were clear. They took place most probably through shallow areas along the southern margin of the Tethys. The finding of a rich Middle Oxfordian ammonite succession at the terminal part of the Washtawa Formation facilitates the litho and biostratigraphic correlation between the Mainland Kachchh and the Wagad region. The analysis of the Middle Oxfordian ammonite succession has allowed dating the studied stratigraphic interval as middle to upper Transversarium Zone. Some recorded taxa such as the west-tethyan form *Larcheria* and the south-tethyan form *Gregoryceras* strengthen these biostratigraphic datings and the so far hypothetical biogeographic expansion of these forms towards the Indo - East-European Province.

## ACKNOWLEDGEMENTS

Thanks are due to Prof. J.H. Callomon for suggestions and discussions, and to Julia Bello and Isabel Pérez Urresti

for their help in making the graphics. The project benefitted from financial support by the CSIR (India) and from a special Marie Curie research award by the European Community. This paper is a part of the research project PCB-94 from the Gobierno de Aragón (CONAI), Spain. The authors would like to thank as well two anonymous referees who made a critical reading of the manuscript and helped much to improve the final version of this paper.

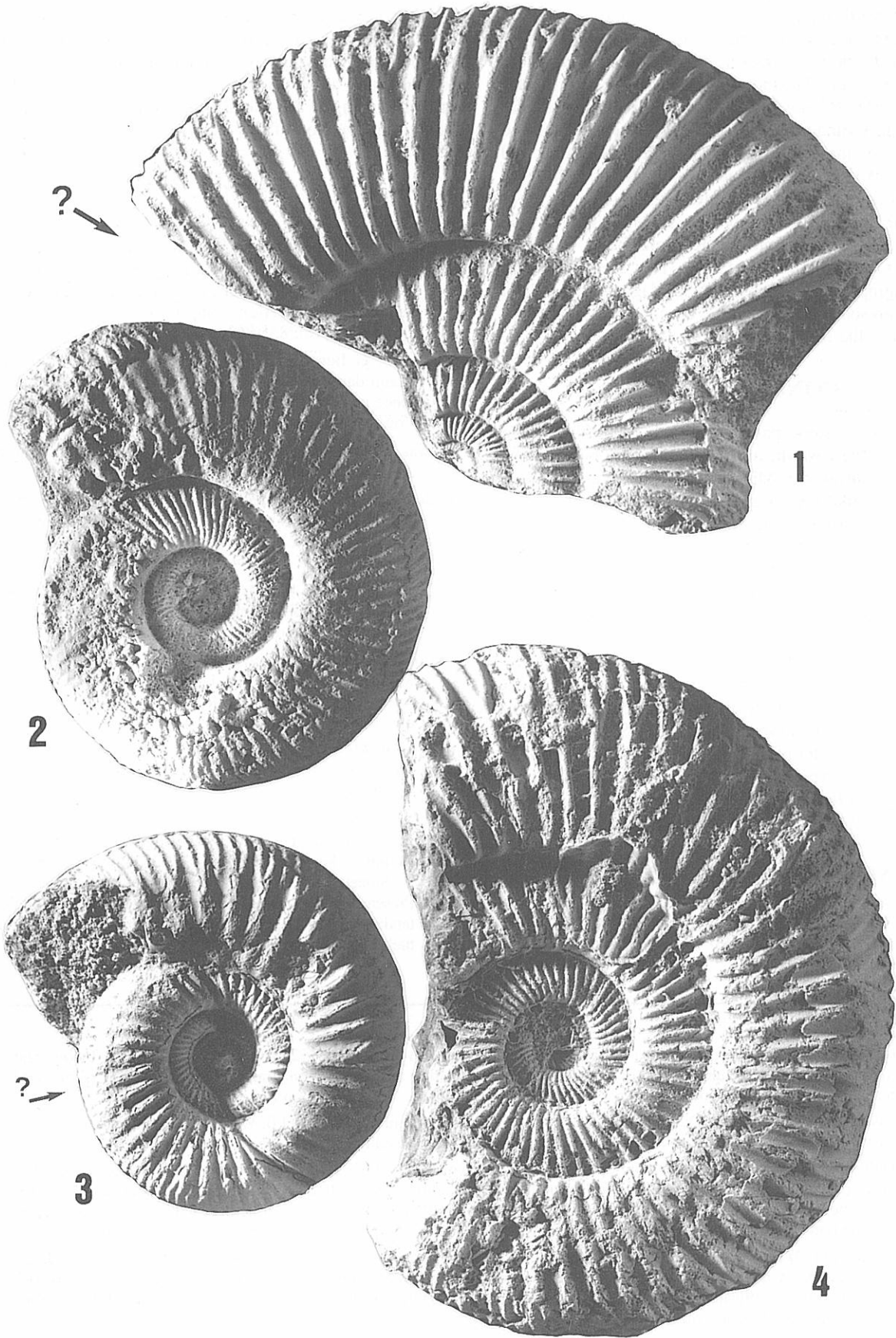
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## Plate I

1. *Perisphinctes* (m *Dichotomosphinctes*) cf. *luciae* De Riaz. Specimen nr. KT.94/9/52. Wagad section, level 9. Incomplete specimen, presumably an adult microconch, showing evolute coiling and massive quadrate to rounded whorl section and biplicate, ribbing with common single ribs. Middle Oxfordian, middle Transversarium Zone. ?Schilli Subzone.
2. *Perisphinctes* (?m) cf. *kiliani* De Riaz. Specimen nr KT.94/8/28. Wagad section. level 8. Wholly septate specimen, presumably an incomplete microconch. Middle Oxfordian, middle Transversarium Zone. ? Schilli Subzone.
3. *Perisphinctes* (m *Beraketites*) cf. *lehmani* Collignon. Specimen nr KT.94/9/61. Wagad section, level 9. Incomplete, possibly juvenile specimen with almost a whole whorl of body chamber, showing evolute coiling, rounded to depressed whorl section and fine biplicate ribbing with occasional intercalaries and trifurcations. Thick parabolic nodes are visible at the beginning of the body chamber, after the constriction. Middle Oxfordian, middle Transversarium Zone. ?Schilli Subzone.
4. *Perisphinctes* (?M) gr. *martelli* Opper-aguilonenesis Meléndez. specimen nr KT.94/6/112. Wagad section, level 6. Wholly septate, presumably a macroconch nucleus, showing moderately evolute coiling, compressed whorl section and dense ribbing with regularly biplicate and single ribs. Middle Oxfordian, Transversarium Zone. The *martelli* group Opper spreads broadly between the Luciaeformis and Schilli Subzones.

All figures (x 1).



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*Manuscrito recibido*: 13 de diciembre, 1994  
*Manuscrito aceptado*: 21 de junio, 1995