Contributions to the Jurassic of Kachchh, Western India. III. The Middle Bathonian ammonite families Clydoniceratidae and Perisphinctidae from Pachchham Island

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Abstract. Marine Bathonian sediments of the Khavda Fonnation exposed on Pachchham Island in Kachchh, western India, are over 200 m thick. Ammonites have been found at only two levels a few meters apart in the upper part of the Formation, in the Goradongar Yellow Flagstone Member. To the rare *Clydonicersa* and *Bullatimorphites* described previously are now added also rare *Micromphalites* and more abundant *Procerites* (*Gracilisphinctes*) arkelli COLLIGNON, a Madagascan species. The faunas of the two levels cannot be distinguished and are therefore treated as a single faunal horizon. Its correlation with the type horizon of *P. arkelli* appears to be exact, and its age is Middle Bathonian, most probably the earlier part corresponding to the Progracilis Zone of Europe.

India, Pachchham, ammonites, Middle Jurassic, Khavda Formation, Progracilis Zone

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Introduction

Bathonian ammonites are very scarce in the Jurassics of Kachchh. During the last decade or so, two fragmentary specimens were first recorded from Kala Dongar ("Black Hills"), and rather more from Gora Dongar ("White 'Hills") on Pachchham Island, Kachchh, Western India (SINGH, JAITLY & PANDEY 1982; SINGH, PANDEY & JAITLY 1983; PANDEY & AGRAWAL 1984a). They belong to the genera Clydoniceras BLAKE, Micromphalites BUCKMAN, Bullatimorphites BUCKMAN, Procerites SIEMIRADZKI and Gracilisphinctes BUCKMAN. The specimens of Clydoniceras and Bullatimorphites have already been described (PANDEY & AGRAWAL 1984b; PANDEY & WESTERMANN 1988). Out of the rest, only the two small, fragmentary and poorly preserved specimens from Kala Dongar, one each of Micromphalites and Gracilisphinctes, have so far been described (JAITLY & SINGH 1984). But there are now numerous well-preserved specimens, 35 in all, of Micromphalites, Procerites and Gracilisphinctes from Gora Dongar so far undescribed, some collected in January 1992. The present paper deals with the description and illustration of these ammonites and discusses their age and distribution.

Biostratigraphy

The Bathonian ammonites to be described here come from two levels in the Goradongar Flagstone Member of the Khavda Formation (FORSICH et al. 1994) (Textfig. 2). The beds consist of 40-50 m of prominently yellowish fossiliferous silty to fine sandy marls and micrites with intercalated slabs of sometimes golden colitic calcarenite. They are exposed in patches all along the hills of the Gora Dongar range (Text-fig. 1). At Sadhara, at the south-eastern end, the ammonites are confined to two levels 2-3 m apart in the upper part of the Member (FURSICH et al. 1994: 124, beds E2d, h).



Text-fig. 1. Map showing localities referred to in the text. Outcrops of Mesozoic rocks as inliers in younger cover ringed in outline

The lower level has yielded Clydoniceras triangulare PANDEY & AGRAWAL, Bullatimorphites (s. s.) n. sp. A PANDEY & WESTERMANN (1988) and Gracilisphincies. The ammonites from the upper level include Clydoniceras pachchhamense PANDEY & AGRAWAL also previously described, and Micromphalites (Clydomphalites) cf. clydocromphalus ARKELL and Gracilisphinctes arkelli COLLIGNON described here.

The next higher level in Gora Dongar to have yielded ammonites - *Macrocephalites* sp. cf. or aff. *madagascariensis* - is the Raimalro Limestone (Textfig 2), 35 m higher.

The Goradongar Flagstone Member is also typically developed throughout the Kala Dongar, and good exposures may be soen below the summit around Pachhmaipir, the highest point on the northerly scarp of the range overlooking the Rann and, at Bhabia Hill, the highest point on Pachchham Island (468 m). Typical local specimens of *Gracilisphinctes* are kept in the temple there (see Plate 5 below), but the precise level from which they come is not yet known.

Measurements and storage

Measurements of specimens are in millimetres, generally taken along the maximum diameter of the preserved shell unless otherwise mentioned. Relative proportions (lower-case letters) are given as fractions of the diameters. The following conventional abbreviations have been used:

- D: diameter of the shell.
- *H*: height of the last whorl measured along the shell diameter; h = H/D.

W: thickness (width) of the whorl where the height has been measured; w = W/D.

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U: diameter of the umbilicus measured along the shell diameter; u = U/D.

Specimens with numbers PG/../.. are lodged in the Palaeontological Laboratory, Department of Geology, Banaras Hindu University, Varanasi 221005, India, whereas those with numbers RUC19931 ...are preserved in the Department of Geology, University of Rajasthan, Jaipur 302004, India.

Systematic descriptions

Superfamily Haplocerataccae ZITTEL 1884

Family Clydoniceratidae S. BUCKMAN 1924

Genus Clydoniceras BLAKE 1905

Type species. Animonites discus J. SOWERBY 1813, Lower Cornbrash, Discus Zone, England.

Clydoniceras sp. indet.

Pl. 1, Fig. 1

Material. One small specimen (PG/172/25b), originally attached to the Micromphalites described below.

Horizon and locality. From the higher level in the Goradongar Flagstone Member, Khavda Formation, north-east of Sadhara.

Dimensions.

	D	h	w	u	₩IH
PG/172/25b	12.9:	0.46	0.32	0.24	0.70

Description. Incomplete small phragmocone, compressed and moderately evolute with subovate whorlsection; maximum inflation at dorsal-third of the whorl-height. Flanks feebly arched, sloping towards the periphery to form a narrow venter. Umbilical wall rather steep, making a rounded obtuse angle with the flank. Ribs fine, concave forwards, confined to the outer, ventral-third of the whorl. Sutures well preserved and typical of *Clydoniceras*.

Remarks. The specimen compares quite well with the figures of the NW-German specimens identified as *Clydoniceras discus planum* DE GROSSOUVRE (WESTERMANN 1958: 57, pl. 12, figs. 5-6; pl. 13, figs. 1-2) in many of the diagnostic characters. But since it is merely a nucleus, no closer assignment can be made. It serves merely to confirm the range of the genus as extending downwards well into the Middle Bathonian.



GORA DONGAR

Text-fig. 2. Summary of the stratigraphy of the Khavda Formation, Pachchham Island, as exemplified by the sections at the eastern end of Gora Dongar, at Sadhara (after FORSICH et al. 1994). The Raimalro Limstone is the equivalent of the Patcham Limestones at Junara on the Kachchh Mainland, which are there dated by ammonites.

Genus Micromphalites BUCKMAN 1923

Type species. *Ammonites micromphalus* PHILLIPS 1871; Middle Bathonian, Progracilis Zone, England.

Subgenus Clydomphalites ARKELL 1952

Type species. *Micromphalites clydocromphalus* ARKELL (1952), Middle Bathonian, central Arabia.

Micromphalites (Clydomphalites) cf. clydocromphalus ArkELL 1952

Pl. 1, Figs. 2, 3

- cf. 1952 Micromphalites (Clydomphalites) clydocromphalus ARKELL: 287, pl. 26, figs. 1, 7, 9; pl. 28, fig. 12; Text-fig. 9.
- cf.? 1958 Micromphalites saint-oursi COLLIGNON: pl. 9, fig. 45 (type).

Material. Two poorly preserved specimens (PG/172/25a & PG/240/8). The former was found associated with the *Clydoniceras* sp. indet. described above.

Horizon and locality. From the higher level in the Goradongar Flagstone Member, north-east of Khari and Sadhara.

Dimensions.

	D	h	w	u	WIH
PG/172/25a	50:	0.52	?	0.11	-
PG/240/8	41:	0.55	0.22	0.12	0.40

Description. Phragmocone discoidal, involute and with keeled venter; maximum inflation at the umbilical shoulder. The surface on the inner whorls is ornamented with broadly rounded primaries dividing into two to three falcoid secondaries, but with maturity these gradually become restricted to the outer third of the whorl-side leaving the umbilical region smooth. The secondaries terminate in nodes giving the appearance of a slightly square-shouldered venter. Keel ser-ated with very fine transverse thread-like lineations.

Remarks. The general sculpture of the shell, i. e. whorl-section, ornamentation and proportions are exactly similar to those in the type material described by ARKELL (see synonymy), from the middle Dhruma Formation (Middle Bathonian) of Jebel Tuwaiq in Arabia. The umbilicus of the present specimens is, however, slightly wider. The specimen figured by ENAY et al.(1987a: pl. 5, figs. 4a, b) gives no additional information.

Micromphalites saintoursi has been described only through its type, which appears to be wholly septate still at its maximum diameter of 100 mm. Inner whorls up to a diameter of 45 mm are concealed, so that a closer comparison with the Indian forms is not possible. But it may well be conspecific. Its significance lies in its co-occurence with *Procerites arkelli* (see below). *M. hourcqi* COLLIGNON (1958: pl. 9, fig. 47) differs in having strong, coarse, curved primary ribbing and a much wider umbilicus - it may be a microconch. It is also considerably younger, occuring at around the level of *Epistrenoceras histricoides*, high in the Upper Bathonian (COLLIGNON 1964: 915; WESTERMANN & CALLOMON 1988: 12).

According to ARKELL (p. 288), the inner whorls of Dhrumaites ARKELL show ornamentation comparable to that of Micromphalites and Clydoniceras. But Clydomphalites can be easily distinguished by its lanceolate whorl-section at all stages of growth. Clydoniceraş (s. s.) discus (J. Sow.) (ARKELL 1951: 33, pl. 2, figs. 2a, b, c) differs in having an oxyconic whorl-section without shouldered venter. It is a macroconch, but its microconch C. (Delecticeras) is even more distinct at the diameters under consideration here, being more involute, compressed and densely ribbed.

Micromphalites (Clydomphalites) sp. indet.

Pl. 1, Figs. 4, 5

Material. Two fragmentary specimens (PG/129/4 & PG/239/10).

Horizon and locality. From the higher level in the Goradongar Flagstone Member, north of Khari and WNW of Sadhara.

Description. Both specimens consists only of quarterwhorls of phragmocone. Compressed, keeled, fastigate whorl-section with maximum thickness at the umbilical shoulder; umbilicus small, its walls vertical with acutely rounded umbilical edge. Lateral surfaces more or less flat, sloping very gently towards the venter to form shoulders at the ventro-lateral edges, with a narrow keel; ornamented with faint and blunt falcoid ribs, the primaries rectiradiate, occasionally bifurcating at mid-height and then turning backward with slight forward concavity.

Remarks. The whorl-section, pattern of ribbing and suture line are similar to those of *M.* (*C*) *clydocromphalus* ARKELL (see above). The *WTH* ratio (0.58) is within the range of the type material at a similar diameter (from 0.61 at 35 mm to 0.51 at 80 mm). Other comparable forms such as *Macromphalites busqueti* (GROSSOUVRE 1919: 412, pl. 14, fig 2a, b), *M. cf. busqueti* (GROSSOUVRE - ARKELL 1952: 284, pl. 27, figs 1-6) and *M. elegans* ARKELL (1952: 286, pl. 26, fig. 8a, b) have more pronounced ventral shoulders and thick and closely spaced ribs. The poor preservation and fragmentary nature of the present specimens make closer determination impossible.

Superfamily Perisphinetaceae STEINMANN 1890

Family Perisphinetidae STEINMANN 1890

Subfamily Zigzagiceratinae Buckman 1920

Genus Procerites SIEMIRADZKI 1898

Type species. Ammonites procerus SCHLOENBACH 1865 (= Perisphinctes schloenbachi (GROSSOUVRE 1907)), Lower Bathonian, NW-Germany.

Procerites cf. schloenbachi (GROSSOUVRE 1907)

Pl. 1, Figs. 6, 7

- cf. 1865 Ammonites procerus SEEBACH- SCHLOENBACH: 38, pl. 30, fig. 1a, b.
- cf. 1907 Ammonites schloenbachi sp. nov. GROSSOUVRE: 8.
- cf. 1958 Procerites schloenbachi (GROSSOUVRE) ARKELL: 181, pl. 21, fig. 9; Text-figs. 62, 66.
- cf. 1958 Procerites (Procerites) cf. schloenbachi (GROSSOUVRE). WESTERMANN: 76, pl. 31, fig. 5.
- cf. 1966 Procerites schloenbachi (GROSSOUVRE) STURAN: 43, pl. 14, figs. 2a, b, Pl. 17, fig. 4 (suture line).

Material. Two fragmentary specimens (PG/110/3 & PG/267/1).

Horizon and locality. From the higher level in the Goradongar Flagstone Member, Gora Dongar, north-west of Sadhara and south-east of Madai Bet.

Description. Both fragments are septate and parts of formerly larger specimens of c. 225 mm diameter, hence macroconch. Phragmocone fairly evolute, whorl-section moderately compressed, ovate to subovate, sides flat to slightly arched joining upward in an obtusely rounded, narrow venter. Umbilical edge obtusely rounded but distinct. Ribbing consisting of strong, rounded, rectiradiate primary folds which originate at the umbilical edge, attain maximum amplitude at quarter to mid height and then fade, leaving the ventral surface smooth.

Remarks. The general features of the specimens, such as their strong primary rib-folds, ovate to subovate whorl-section, moderately evolute umbilicus and suture-line are compatible with their assignment to Procerites, although in the absence of independent evidence of age, they could also be identifiable as other perisphinctid genera such as e.g. Parachoffatia MANGOLD of the Upper Bathonian-Callovian. The rectiradiate, strong, persistent primaries and the smooth venter of the outer whorls of the phragmocone, compressed whorl-section resemble those of Procerites schloenbachi (GROSSOUVRE) as illustrated e.g. by ARKELL (1958). The thick primaries or primary folds in the present specimens are also comparable with those in Procerites cf. tmetolobus BUCKMAN (ARKELL (1958: 191, pl. 25, fig. 2), but this species has fasciculate ribs. In view of the fragmentary nature of the specimens and in the absence of any knowledge of the inner whorls, little more can be said. Because of their association with P. arkelli described below, the possibility that they represent merely the extremes at one end of the range of variability of that species cannot be ruled out. But as they stand, they do give the appearance of being distinct.

Subgenus Gracilisphinctes BUCKMAN 1920

Type species. Ammonites gracilis J. BUCKMAN 1844 (non ZIETEN 1830) (= Procerites progracilis Cox & ARKELL 1950), Middle Bathonian, Progracilis Zone, England.

The proliferation of generic nominal taxa in the Perisphinctidae is notorious. Now that phyletic relationships have become clearer and classification at specific level strives increasingly towards the recognition of isochronous, morphologically variable palaeospecies approximating, as far as this is ever possible palaeontologically, to once-living biospecies, the natural units of phylogeny, generic classification can be correspondingly simplified. The material now before us is abundant, well preserved and geologically certainly isochronous. It can therefore be regarded as merely a transient in the principal evolutionary lineage of the Perisphinctidae. This can now be followed smoothly from the Upper Bajocian through the Callovian into at least the Oxfordian, where lies the typespecies of Perisphinctes itself. Nevertheless, for historical reasons and convenience, separate generic names are still applied to successive segments of the lineage. The boundaries between them are arbitrary and transitional, so that demarcation becomes uncertain. The Perisphinctidae of the Bathonian are conventionally divided into chronologically consecutive segments: Procerites [M]/Siemiradzkia [m] for the range Lower - early Upper Bathonian, and Parachoffatia [M]/ Homeoplanulites [m] for the late Upper Bathonian and Lower Callovian. ([M] and [m] refer to dimorphic macro- and microconch respectively). Procerites has itself been much subdivided in the literature. The type-species (see above) is of Lower Bathonian age. The forms from the Middle Bathonian and upwards have usually been assigned in part also to Procerites but mostly to Gracilisphinctes, either as distinct morphogenus (e.g. COLLIGNON) or morphosubgenus of Procerites (e.g. ARKELL). The forms to be described below resemble morphologically the group of Gracilisphinctes more closely than that of Procerites s. s., certainly less closely than Parachoffatia. We adopt a compromise, therefore, in retaining Gracilisphinctes as a chrono-subgenus of Procerites. Its type-species is of early Middle Bathonian age.

Procerites (Gracilisphinctes) arkelli COLLIGNON 1958

Pl. 1, Fig. 8; Pl.s 2-5; Text-figs. 3a-c

1958 Gracilisphinctes arkelli sp. nov. - COLLIGNON: pl. 6, figs. 31-33 (holotype: fig. 31a, b).

- 1958 Gracilisphinctes lemoinei sp. nov. COLLIONON: pl. 7, fig. 35 (holotype).
- 1958 Gracilisphinctes andranomantsyensis sp. nov. -COLLIGNON: pl. 7, figs. 36, 36a (holotype).
- non 1983 P.? (Procerites?) arkelli (COLLIGNON) SANDOVAL: 448, pl. 45, fig. 1 (= P. hodsoni).

Material, 26 specimens from Gora Dongar and 2 seen at Pachhmaipir temple, Kala Dongar; all macroconchs. Most of the material was collected by one of us in the course of systematic mapping as part of a project leading to a Ph.D.

Dimensions.

Horizon and locality, From one or other or both faunal levels in the Goradongar Flagstone Member, at various localities along Gora Dongar, between Khavda in the west and Sadhara in the east (Text-fig. 1). The occurences were sparse and scattered, so that from which of the two horizons a specimen meme could not always be deturmed. Al some localities, however, specimens were found at both the levels in succession. They could not be distinguished morphologically, so that the two levels may be regarded as biochronologically isochronous and their faunas combined into effectively a single faunal biochrono.

		D	h	w	u	WIH
	(Pl. 5, Fig. 3)	230:	0.39	-	0.28	-
PG/110/51	(Pl. 3, Fig. 3)	230:	0.41		0.28	-
PG/129/19	(Pl. 3, Fig. 1)	220:	0.42	0.28	0.27	0.67
PG/139/14	-	215:	0.42	0.27	0.27	0.65
PG/204/7	(Pl. 4, Fig. 1)	210:	0.42	0.31	0.25	0.73
PG/208/1	(Pl. 4, Fig. 2)	210:	0.45	0.31	0.26	0.68
PG/268/1	(Pl. 5, Fig. 1)	210:	0.43	0.29	0.28	0.66
PG/233/1	(Pl. 4, Fig. 3)	200:	0.43	0.31	0.26	0.73
PG/204/5	(Pl. 2, Fig. 1)	190:	0.43	0.29	0.26	0.67
PG/180/3	-	160:	0.46	0.32	0.25	0.68
	-	125:	0.46	0.33	0.27	0.72
PG/204/6	(Pl. 3, Fig. 2)	115:	0.43	0.33	-	0.77
PG/139/1	-	90:	0.44	0.32	0.26	0.74
PG/139/3	(Pl. 1, Fig. 8)	70:	0.42	0.30	0.31	0.71
PG/208/1	(Pl. 4, Fig. 2)	65:	0.43	0.38	0.35	0.89
PG/204/6	(Pl. 3, Fig. 2)	60:	0.39	0.35	-	0.88
PG/139/3	(Pl. 1, Fig. 8)	55:	0.42	0.34	0.33	0.87
paratype	(Collignon: pl. 6, fig. 33)	150:	0.42	0.34	0.29	0.81
holotype	(Collignon: pl. 6, fig. 31)	70:	0.42	0.35	0.29	0.83

Description. Coiling evolute, spiral half-whorl constant 1.42 (pl. 2); whorl-section of the phragmocone becoming increasingly involute and compressed during growth, changing from subquadrate to ovate subtrigonal, the inner whorls becoming increasingly covered in the umbilicus; umbilical edge well rounded. Maximum size of the phragmocone 200-230 mm; bodychambers not preserved, but strongly egressing umbilical seams indicate a former extent of c. 0.75 whorl, giving an estimated maximum adult diameter of c. 350-400 mm. Ribbing on the inner whorls regular and strong, the primaries straight and nearly rectiradiate, c. 35-40 per whorl, dividing indistinctly on the flanks at mid-height into sheaves of 3-4 secondaries, wholly covered on the inner whorls, only mildly variocostate, the primaries soon fading without marked decrease in density, the secondaries persisting on the venter, sometimes to the end of the adult phragmocone, the adult bodychamber smooth and strongly contracted over the egressing umbilical seam (pl. 4, fig. 1, pl. 5, figs. 2a, 3a). Inner whorls with strong constrictions (pl. 2) that fade but

may persist (pl. 5, fig. 2a). Septal sutures perisphictid, moderately incized, delicately florid and interlocking on the middle whorls, typical of *Gracilisphictes*, the umbilical lobe moderately retracted with many auxiliaries (text-fig. 3a-c).

A notable feature of the assemblage as a whole is its narrow range of variability (see dimensions): both the umbilical width, the relative inflation (*WHJ*) and the ribbing-density are remarkably uniform. There can be little doubt that the assemblage is monospecific.

Comparisons and age. The strongest resemblance by far to anything in the literature is to COLLIGNON's species from Madagascar. The agreement between the type and the nucleus shown on pl. 1, fig. 8 is almost exact, as is that between the largest specimen figured by COLLIGNON (pl. 6, fig, 33, diameter 150 mm) and the Indian specimens shown on pl. 2, pl. 4, fig. 2a and pl. 5, fig. 3a.

Elsewhere, comparable forms have been described so far only from Europe. The closest is probably



Text-fig 3. Septal sutures of three specimens of *Procertes* (*Gracilisphinctes*) arkelli COLLIGNON. a: PG/268/1, at diameter 180 num; b: PG/204/6, at 200 num; c: PG/129/18, at 225 num; all x0.85.

P. (G.) progracilis Cox & ARKELL (1950: 94, nom. nov. pro Amm. gracilis J. BUCKMAN in MURCHISON 1844, non ZIETEN 1830), index of the early Middle Bathonian Progracilis Zone (text-fig. 4). The holotype (refigured by S. BUCKMAN 1920, pl. 193, ARKELL 1958: 174, text-fig. 63) is crushed, but two chorotypes come near. ARKELL's uncrushed pl. 28, fig. 1, text-fig. 72.3 resembles pl. 4, fig. 1, but is slightly more evolute: at 140 mm, the maximum diameter of the preserved phragmocone, the proportions are 0.39, 0.24, 0.31, which lies well outside the range of the Indian assemblage listed above. His nucleus on pl. 28, fig. 2, maximum diameter 70 mm, closely resembles that shown here on pl. 1, fig. 8. Other English specimens of the same age are all more evolute. Three specimens of P. progracilis recently described from Germany also resemble the Indian forms closely. P. progracilis hahni WESTERMANN & JORDAN from Hildesheim (1990: 45, pl. 1, fig. 1), shows inner whorls with regular rectira-



Text-fig. 4. The standard NW-European chronostratigraphy of the Bathonian as reference time-scale for dating the faunal horizon of *Procerites arkelli* in the Goradongar Vellow Flagstone Member of the Khavda Formation on Pachchham Island. (Note that the Herveyi Zone of the basal Callovian is the fornner Macrocophalus Zone renamed, following the discovery that the zonal index-species, *M. macrocophalus*, does not in fact occur in its nominal Zone: see CALLOMON et al. 1992).

diate ribbing remarkably like that of the specimen on P1.2, from which it again differs principally in becoming more evolute in the middle whorls: u = U/D = 0.37 at 160 mm compared with 0.26. *P. progracilis* from Swabia figured by DIETL (1990, text-figs. 3, 4) is more involute, the specimen of text-fig. 3 having u = 0.28 at 175 mm, compared with 0.26. Despite these resemblances, though, there are consistent differences besides involuteness, already mentioned. The European forms all have rather coarser secondary ribbing, ovate whorl-sections and broader venters. These justify retention of the Madagascan name for the Indian species.

Material in Europe from the Progracilis Zone is in fact relatively scarce. Much better known are the earlier forms of *Procerites* (sensu stricto) from the Lower Bathonian, Zigzag and Tenuiplicatus Zones. They have been described under a long list of names, including *P. tmetolobus* BUCKMAN 1923, *P. clausiprocerus* (BUCKMAN 1925) and *P. subprocerus* (BUCKMAN 1926) (for modern revision, see ARKELL 1958). A wide selection has been figured by TORRENS (1987, pls. 4, 6, 7). Most are probably no more than variants of the oldest named species, *P. schloenbachi* (GROSSOUVRE 1907) already discussed above. As an assemblage they are consistently more evolute and strongly ribbed than *P. arkelli*, differences that distinguish *P. s. s.* from *P. (Graciliphinetes)*.

Upwards, almost nothing appears to have been described so far from the later Middle Bathonian. Subcontractus and Morrisi Zones. Forms of the Gracilisphinctes morphology do, however, range up into the Hodsoni Zone of the early Upper Bathonian. P. hodsoni ARKELL itself (1958: 190, pl. 25, fig. I and p. 187, text-fig. 68.3) has the compressed, involute, densely-ribbed middle whorls of P. arkelli but lacks its differentiation of primary and secondary ribbings, which merge into each other. The differences between P. progracilis and P. hodsoni are well brought out on comparing specimens of the two species illustrated by WESTERMANN & JORDAN (1990, pl. 2, fig. I of the former with pl. 4, fig. 3 and pl. 5 of the latter). The primaries of P. hodsoni as exposed in the umbilicus have a prorsiradiate curvature seen neither in P. progracilis nor in P. arkelli, Other species of the Hodsoni Zone, such as P. quercinus (TERQUEM & JOURDY) (ARKELL 1958: 187, text-fig. 68 and p. 194, text-fig. 70, pl. 25, figs. 4, 5) are all very much more evolute.

The most probable age of the assemblage from Kachchh is therefore Middle Bathonian, earlier part, Progracilis Zone, which is what had always been claimed for the age of *P. arkell* in Madagascar, rather than the later Subcontractus or Morrisi Zones. With the large collection now available from India to amplify our understanding of this species, the residual doubts as to its precise age expressed previously (Hodsoni rather than Progracilis Zone: WESTERMANN & CALLOMON 1988: 13) can be finally laid to rest. It is remarkable that the only known occurrence of *Micromphalites* in Britain should also have coincided with *Procerites* of the Progracilis Zone

Concluding remarks. The ammonite faunal horizons in the Bathonian of Kachchh are too few and dispersed in the succession to allow much in the way of general conclusions. The apparently exact correlation with the *Graciliphinctes* beds of Madagascar is pleasing but not surprising: the close similarities between the Jurassic faunas of Madagascar and of Kachchh have long been well known, reflecting merely the proximity of the two regions before rifting formed the Indian Ocean. The predominance of perisphinctids mirrors that in beds of the same age in northwestern Europe and is probably a climatic/latitudinal effect. Insofar as the European distributions reflect a Subboreal or Submediterranean Province on the northern margins of the Tethys, so the Indo-Malgach, or Ethiopean, or East African Province of authors could be regarded as a Subaustral Province on the southern margins of the Tethys, in the Bathonian as at other times. The differences between *Procerites progracilis* of Europe and *P. arkelli* of Kachechh and Madagascar are outweighed by the similarities and need be no more than geographically subspecific. The presence of rare *Clydoniceras* and *Micromphalites* indicates connections with the more tropical seas of Arabia to the north, from which they were probably only occasional stragglers, just as was the case in Europe.

There remains, however, an unresolved conflict of evidence in correlations with the Middle Jurassic of Arabia based on Micromphalites. The specimens of M. (Clydomphalites) described above are, by association with P. arkelli, of early Middle Bathonian age, Progracilis Zone. In Arabia, they occur together with Micromphalites cf. busqueti (GROSSOUVRE) sensu ARKELL (1952, pl. 27) and spp. (pl. 28), above Tulites. But in France M. busqueti occurs in undoubted Lower Bathonian, and a specimen of M. (C.) clydocromphalus itself has been recorded from the Lower Bathonian of Morocco (ENAY et al. 1987b: 114). Both these are from levels below Tulites. Assuming the ages of M. clydocromphalus from Arabia and Morocco to be the same, and assuming those of M. cf. busqueti of Arabia sensu ARKELL and of M. busqueti of France to be the same, all Lower Bathonian, ENAY et al. (1987a: 43) were led to conclude that it is the Tulites from Arabia whose age must be reassigned: that they must be older than those from Europe, which are all middle Middle Bathonian in age. But the Arabian Tulites, although perhaps specifically distinct, are so similar to true Tulites, as opposed to e.g. T. (Rugiferites), which occurs a little earlier (TORRENS 1974: 587), or Morrisiceras, which is a little later, that such a disparity in ages seems hard to accept. An alternative interpretation might be that both M. clydocromphalus and M. cf. busqueti are longer-ranging in Arabia than in Europe and of later Middle Bathonian age than is Tulites s. s., as ARKELL had assumed. Some of his M. cf. busqueti could, for instance, be equally well compared with M. micromphalus (PHILLIPS), which is certainly already of Middle Bathonian age, Progracilis Zone. The Indian forms of Clydomphalites would then also support the idea of a longer-ranging, only slowly evolving group. Where the "center of evolution" might have lain, and who migrated from where to where, when, is no more demonstrated by the occurrences in a single faunal horizon (D5) in Arabia, albeit widely distributed, than in the scattered occurrences in Europe, Morocco or Kachchh.

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Plates 1-5

(All specimens from the Goradongar Flagstone Member of the Khavda Formation, Middle Bathonian, Gora Dongar, Pachchham Island, Kachchh.)

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Fig. 1. Clydoniceras sp. indet.

Wholly septatenuc leus (PG/172/25b), Gora Dongar, north-east of Sadhara. a: x1. b: x4. c: x4.

Figs. 2-3. Micromphalites (Clydomphalites) cf. clydocromphalus ARKELL.

- 2. Wholly septate right lateral view (PG/172/25a), Gora Dongar, north-cast of Sadhara, x].
- Wholly septate (PG/240/8), Gora Dongar, north-east of Khari. a: left lateral view showing umbilicus, x1. b: right lateral view showing ribbing, x1. c: x2.
- Figs. 4, 5. Micromphalites (Clydomphalites) sp. indet.
 - Septate fragment (PG/129/4), Gora Dongar, north of Khari, x1.
 Septate fragment (PG/239/10), Gora Dongar, WNW of Sadhara. a, b:x1.c:x2.
- Figs. 6, 7. Procerites sp. cf. schloenbachi (GROSSOUVRE).
 - 6. Wholly septate fragment (PG/110/3), Gora Dongar, north-west of Sadhara. a: side-view. b: whorl-section, both x0.5.
 - 7. Wholly septate fragment (PG/267/1), Gora Dongar, south-east of Madai Bet. a, b: x0.5.
- Fig. 8. Procerites (Gracilisphinctes) arkelli COLLIGNON.

Wholly septate nucleus (PG/139/3), Gora Dongar, north-west of Khari. a, b: side and ventral views, xl.



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Fig. I. Procerites (Gracilisphinctes) arkelli COLLIGNON.

Wholly septate nucleus (PG/204/5), Gora Dongar, north of Khari. a: side-view, x1. b: slightly different illumination, x0.6. c: ventral view, x0.6. d: apertural view, x0.6.



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Plate 3

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Figs. 1-3. Procerites (Gracilisphinctes) arkelli COLLIGNON.

- La.e. Wholly septate (PG/129/19), Gora Dongar, north of Khari, x0.6.
 Fragmentary septate phragmocone(PG/2046), Gora Dongar, north of Khari, x0.6.
 Wholly septate, somewhat crushed (PG/110/51), Gora Dongar, north-west of Khari, x0.5.



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Figs. 1-3. Procerites (Gracilisphinctes) arkelli COLLIGNON.

- 1. Wholly septate (PG/204/7), Gora Dongar, north-west of Kinari. a: probably complete adult phragmocone retaining traces of the uncoiling umbilical seam extending over another 3/4 whorl, estimated final diameter 340 mm, x0.5. b: apertural view, x0.5.
- 2. Wholly septate (PG/208/1) Gora Dongar, north-west of Khari. a: side-view. b: apertural view across the line B-C on a. c: ventral view of the outer fragment along the line A-B on a, all x0.5. 3. Wholly septate probably complete adult phragmowne of an involute variant (PG/233/1), Gora Dongar, north of Sadhara,
- x0.5.



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Figs. 1-3. Procerites (Gracilisphinctes) arkelli COLLIGNON.

- 1. Complete septate, adult phragmocone (PG/268/1), Gora Dongar, south-east of Khavda, x0.5.
- 2a, b. Side and ventral views of a septate nucleus with uncoiling seam off ormer adult bodychamber preserved.
- 3a, b. Complete adult phragmocone also retaining umbilical seam, indication former bodychamber with a final diameter of c.340 mm, seen in right and left lateral views respectively.

Figs. 2, 3: Goradongar Flagstone Member, Kala Dongar, two specimens seen in Pachlunaipir temple, from colour-slides, x 0.5.



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