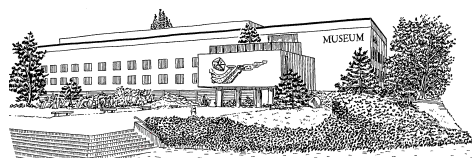


R E V U E D E PALÉOBIOLOGIE

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Ammonites of the genus *Perisphinctes* WAAGEN, 1869 from the Oxfordian of Kachchh, western India

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Abstract

The majority of ammonites occurring in the Oxfordian rocks of the Kachchh Basin in western India belong to the genus *Perisphinctes* WAAGEN, 1869. Although these ammonites are closely related and share an overall similar morphology, they can be divided into several morphospecies based, for example, on their proportional dimensions, whorl section, and ornamentation. Most of these taxa have short stratigraphic ranges and therefore serve as excellent index fossils. In this publication more than 300 ammonites, collected from the Oxfordian succession of the Kachchh Basin, have been assigned to 43 taxa of the genus *Perisphinctes*. The material considerably refines the existing knowledge on ammonite taxonomy and biostratigraphy in the basin and promotes intercontinental correlation e.g., with the ammonite zonation of Europe. Nine ammonite levels have been identified, representing Early (Cordatum Zone), Middle (Plicatilis, Transversarium zones), and Late (Bifurcatus Zone) Oxfordian.

Keywords

Ammonoids, Oxfordian, taxonomy, biostratigraphy, Kachchh Basin, India.

Contents

I. Introduction.....	483
II. Geological setting and stratigraphic framework	484
III. Systematic palaeontology.....	487
Subgenus <i>Perisphinctes</i>	488
Subgenus <i>Kranaosphinctes</i>	491
Subgenus <i>Arisphinctes</i>	495
Subgenus <i>Liosphinctes</i>	508
Subgenus <i>Dichotomosphinctes</i>	510
Subgenus <i>Dichotomoceras</i>	520
IV. Taxonomic remarks.....	526
V. Biostratigraphy.....	528
Acknowledgements.....	536
References.....	536
Appendix.....	540

I. INTRODUCTION

Cephalopods of the Kachchh Basin have been studied for more than a century beginning with the taxonomic monographs of WAAGEN (1873-1875) and SPATH (1927-1933). In subsequent decades major progress has been achieved in various aspects of Kachchh geology, such as litho- and biostratigraphy, leading to a more precise understanding of the rock succession of the basin (e.g., AGRAWAL, 1956; BISWAS, 1982, 1991, 1993; SINGH *et al.*, 1982, 1983; PANDEY & AGRAWAL, 1984; AGRAWAL

& PANDEY, 1985; KRISHNA & WESTERMANN, 1987; PANDEY & WESTERMANN, 1988; PANDEY *et al.*, 1994; PANDEY & CALLOMON, 1995; JAIN *et al.*, 1996; KRISHNA *et al.*, 1996a, b, 1998, 2000, 2009a, b, c). Although numerous ammonites have been collected by different working groups, no modern and comprehensive taxonomic study, including detailed illustrations of the Oxfordian ammonite fauna, combined with precise stratigraphic data, is yet available.

During three recent field surveys in the Kachchh Basin, which mainly concentrated on the richly fossiliferous

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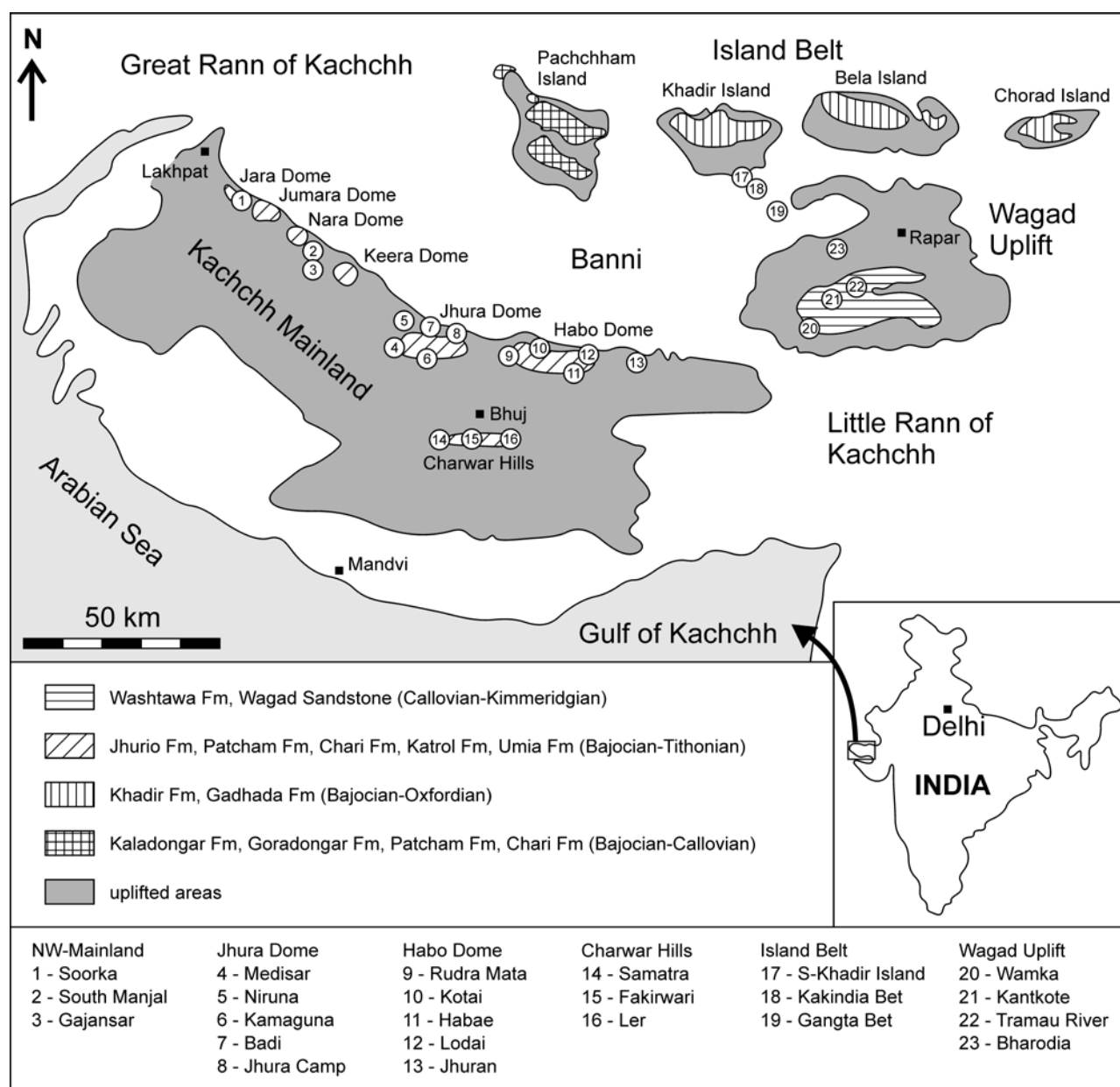


Fig. 1: Geological sketch map of the Kachchh Basin showing the localities mentioned in the text (modified after FÜRSICH *et al.*, 2004a, 2005).

Oxfordian succession, more than 800 ammonoids were collected. Sections were measured and fossils were collected with high stratigraphic resolution. Additionally, the material collected by the Late John H. CALLOMON during his journeys to Kachchh between the years 1990 and 1998 has been studied at the Oxford University Museum of Natural History. The present publication, covering members of the genus *Perisphinctes* WAAGEN, 1869, is the second in a series planned to enlarge our knowledge of the Upper Jurassic cephalopod fauna of the Kachchh Basin (see ALBERTI *et al.*, 2011).

II. GEOLOGICAL SETTING AND STRATIGRAPHIC FRAMEWORK

The Kachchh Basin, situated in western India (Fig. 1), formed following rifting between India and Africa in the Late Triassic (BISWAS, 1982, 1991, 2005). Jurassic outcrops mainly occur in three uplifted areas, the so-called Kachchh Mainland, the Wagad Uplift, and the Island Belt. The Kachchh Mainland is delimited by the Arabian Sea towards the south and the salt marshes of the Great Rann of Kachchh towards the north. While the southern part of the Kachchh Mainland is covered

by Deccan traps, the northern part is characterized by an E-W oriented chain of domal structures offering outcrops of Jurassic rocks ranging from Bajocian to Tithonian in age (FÜRSICH *et al.*, 2004a, b; KRISHNA *et al.*, 2009a). Furthermore, a chain of outcrops south of the district capital Bhuj displays Jurassic strata uplifted along the Katrol Hill Fault (i.e. Charwar Hills; BISWAS, 1993). The Oxfordian succession on Kachchh Mainland is characterized by strong condensation and sedimentary gaps. The sections investigated start within the Upper Callovian Gypsiferous Shale member, which consists of argillaceous silt with several concretionary layers and abundant secondary gypsum (for a broad lithostratigraphic framework of the Oxfordian of the Kachchh Basin see Fig. 2, for representative sections see Fig. 3). The shales gradually coarsen into the Dhosa Sandstone member comprising fine sandstone beds characterized by occasional cross-bedding and traces of bioturbation. The base of the Dhosa Sandstone member seems to be diachronous, being Late Callovian (Athleta Zone) in the east and Early Oxfordian (Cordatum Zone) in the west (J. H. CALLOMON, pers. comm., 2000). The occurrence of allochthonous, ferruginous ooids marks the boundary with the Dhosa Oolite member, whose top, the Dhosa Conglomerate Bed, serves as an important marker horizon throughout the Kachchh Mainland. This strongly condensed unit exhibits a series of intricate features (see ALBERTI *et al.*, 2012). It consists of concretionary slabs floating in a much finer matrix often with oncoids at

the top (e.g., at Jara and Jumara domes, Fig. 3A). The concretions are reworked from the underlying Dhosa Oolite member, and their ammonite content, pointing to an Early Oxfordian age (Cordatum Zone; ALBERTI *et al.*, 2011), is autochthonous. The matrix surrounding the concretionary slabs is highly fossiliferous with abundant, reworked ammonites from several biozones (Cordatum to Transversarium zones; compare SINGH, 1989; KRISHNA *et al.*, 1996b, 2009b, c). Furthermore, in a few outcrops in the Habo Dome the conglomeratic matrix fills crevices cutting down into thin layers of older sandstones (e.g., at Rudra Mata, Fig. 3B). After a depositional gap, sedimentation resumed in the late Early Kimmeridgian with the Katrol Formation (KRISHNA & PATHAK, 1993; KRISHNA *et al.*, 1996b, 2000; also see ALBERTI *et al.*, 2011).

While the Oxfordian succession on Kachchh Mainland is characterized by strong condensation and comprises barely more than 10 m in thickness, the same time interval is represented by several hundred metres of sediments at the Wagad Uplift. However, most parts of this succession are almost devoid of fossils and major concentrations of ammonites occur only in the Middle Oxfordian Kantkote Ammonite Beds (Fig. 3C). Their ammonite content has been partly studied in the last few years (e.g., KRISHNA *et al.*, 1996b, 1998, 2009a, b, c). Most of the material studied from the Wagad Uplift has been collected from this unit, only one specimen comes from the slightly higher Patasar Shale member.

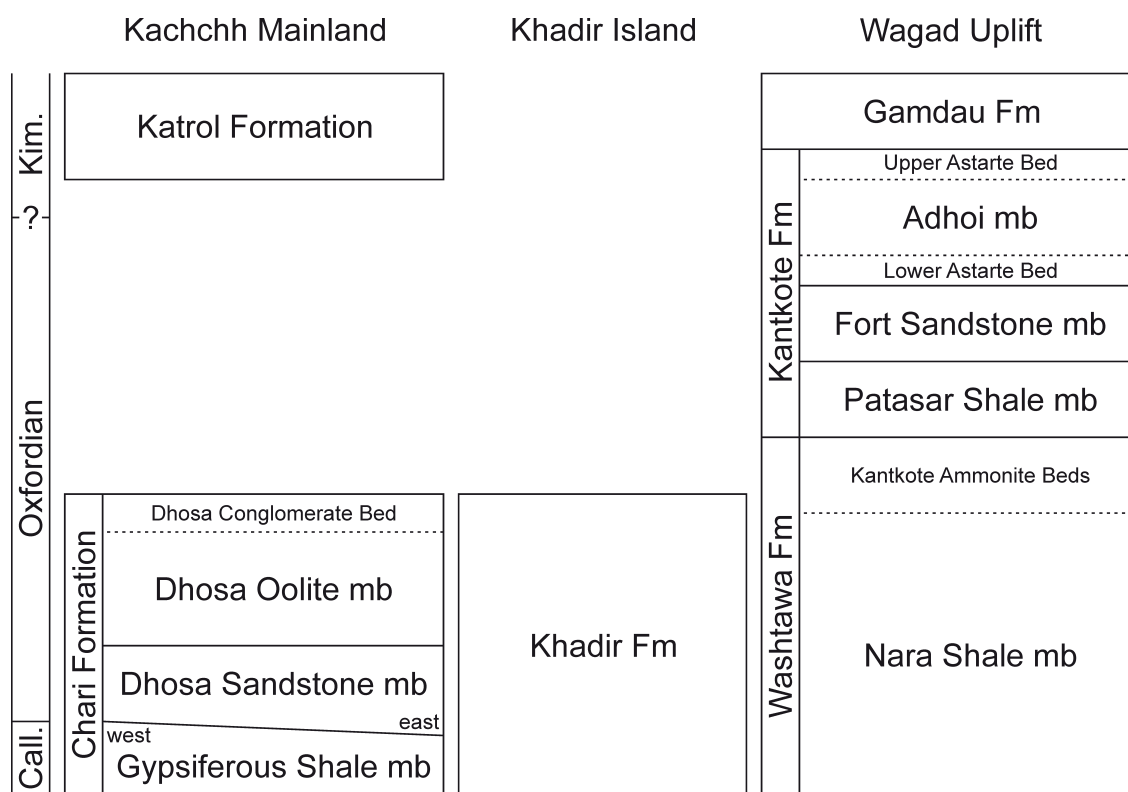


Fig. 2: Lithostratigraphic framework of the Kachchh Basin (Call. – Callovian; Kim. – Kimmeridgian).

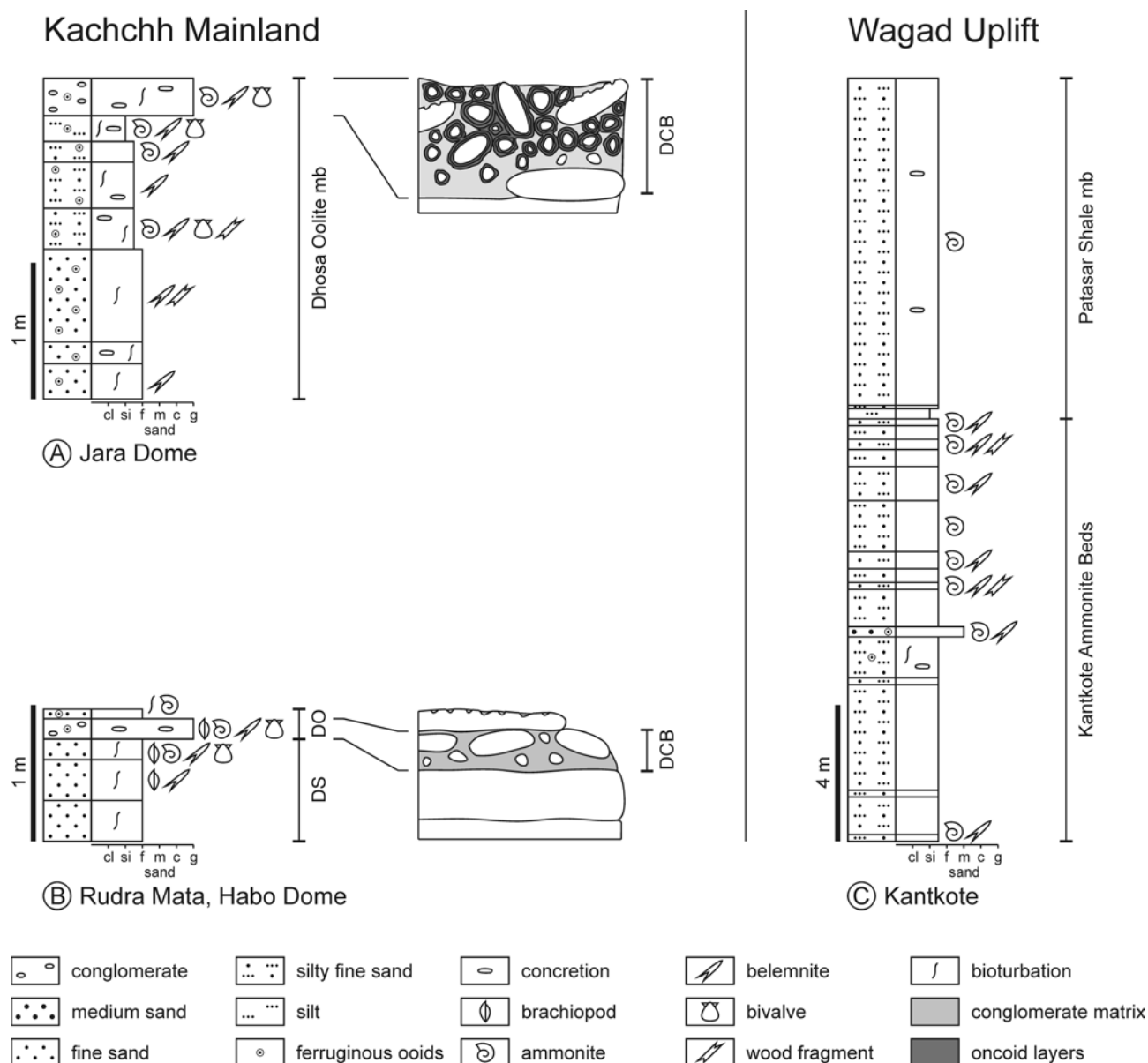


Fig. 3: Sections through the Oxfordian of the Kachchh Basin. A-B. Sections through the upper part of the succession on Kachchh Mainland with detailed sketches of the Dhosa Conglomerate Bed (DCB), which is characterized by reworked, concretionary slabs floating in a fine-grained, highly fossiliferous matrix. Note the thin layer of Dhosa Oolite (DO) on top of the Dhosa Conglomerate Bed (DCB) at Rudra Mata, Habo Dome (B). C. Section southwest of Kantkote Village in the Wagad Uplift. Well-cemented, silty sandstone beds with abundant ammonites belong to the Kantkote Ammonite Beds which are overlain by the thick, poorly indurated Patasar Shale member, in which ammonites are rare.

The Island Belt consists of several smaller uplifted areas, which are completely surrounded by the salt marshes of the Great and Little Rann of Kachchh. These areas become true islands only during monsoonal floods and are otherwise well connected by roads. While most outcrops of the Island Belt display older strata, Oxfordian rocks are exposed on Khadir Island as well as on some smaller islets towards the southwest (i.e. Kakindia Bet

and Gangta Bet). In the present study, ammonites from a section measured at the southernmost tip of the Khadir Island have been included. At this locality, cephalopods are comparatively rare and have been found only in one horizon. However, it should be noted, that these specimens are reworked and indicate the presence of several ammonite levels (Cordatum to Transversarium zones).

III. SYSTEMATIC PALAEOONTOLOGY

All uplifts in the Kachchh Basin, known to contain outcrops of Oxfordian rocks, have been investigated and sections have been measured. The 311 specimens of the genus *Perisphinctes* WAAGEN, 1869 described in this publication come from all these localities, except for Gangta Bet, a small islet in the Little Rann of Kachchh. Localities mentioned in the text are included in Fig. 1. Table 1 contains the geographic coordinates of the sections from which the ammonites described here have been collected.

Table 1: Geographic coordinates of the sections yielding specimens of *Perisphinctes* WAAGEN, 1869.

Locality	Latitude	Longitude
Jara Dome	N 23°43'26.7"	E 068°59'26.9"
Jumara Dome	N 23°41'13.6"	E 069°02'51.0"
Medisar	N 23°23'38.2"	E 069°30'18.5"
Kamaguna	N 23°22'48.8"	E 069°33'34.5"
Jhura Camp	N 23°24'54.2"	E 069°36'26.3"
Rudra Mata	N 23°22'11.7"	E 069°44'55.0"
Kotai	N 23°23'23.1"	E 069°46'48.9"
Lodai	N 23°22'08.4"	E 069°53'30.3"
Samatra	N 23°10'38.5"	E 069°28'58.1"
Ler	N 23°11'40.9"	E 069°45'41.4"
S-Khadir	N 23°47'00.3"	E 070°22'12.9"
Kantkote	N 23°28'46.0"	E 070°27'26.3"
Tramau River	N 23°29'29.9"	E 070°29'42.3"

Most of the prominent studies on ammonites of the genus *Perisphinctes* WAAGEN, 1869 are based on material combining internal whorls (or nuclei), juveniles, and full-grown adults to comprehensively characterize a species (e.g., ARKELL, 1935-1948; ENAY, 1966; MALINOWSKA, 1972a, b; BROCHWICZ-LEWINSKI, 1980a, b; MÉLENDEZ, 1989; GYGI, 2000, 2001; GLOWNIAK, 2002). In contrast, the material from the Kachchh Basin suffers from a series of limitations with most ammonites found only as internal whorls. This problem was seen already with the material of WAAGEN (1873-1875) and SPATH (1927-1933) and also hindered the current authors from describing all ontogenic stages of the present taxa. Nevertheless, although the collected material does not allow an entire revision of the genus in the Kachchh Basin, it allows a modern presentation of a series of taxa from this area as well as important biostratigraphic correlations.

The identified ammonites have been measured using a Vernier Caliper. Cross-sections through certain specimens have been cut to study their allometric growth; these have been measured digitally after scanning the cross-section. Dimensions in the tables in the appendix are given in millimetres. The measurements and abbreviations used are explained in Fig. 4. Numbers in parantheses are

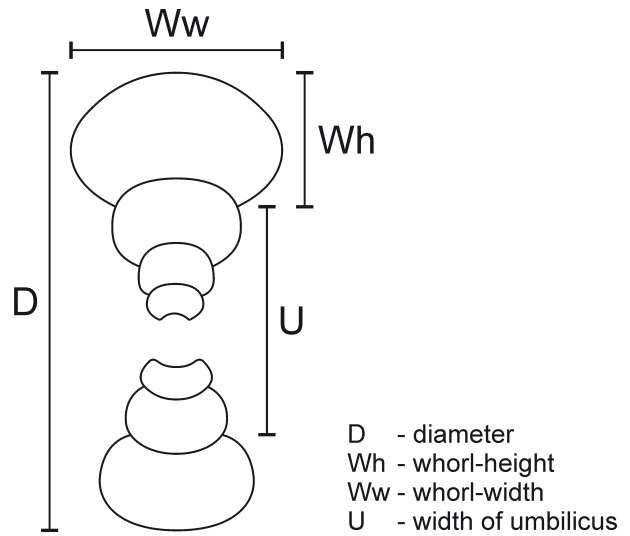


Fig. 4: Measured dimensions and used abbreviations of the ammonoids.

proportional dimensions as percentage of diameter. Rib curves, suture lines, and other morphological features are illustrated by drawings depending on the preservation quality of the material. To shorten the synonymy lists only first descriptions, the most prominent monographs, or references pointing to the occurrence of the taxa in the region (India, Madagascar, East Africa) have been included. A few terms used in the descriptions of the taxa, may need explanation which is provided in the following.

Variocostate: the style of ribbing changes from fine or moderately thick on the inner whorls to very thick or fold-like on the outer whorls or on the body whorl. This change can be sudden (e.g., in *Perisphinctes* s.s.) or gradual along a longer stretch of the whorl (as in *Arisphinctes*).

Varicostate: the style of ribbing changes from very fine or fine and dense on the inner whorls to moderately thick and more distant on the outer whorls. This change occurs continuously throughout ontogeny (compare CALLOMON, 1984).

Isocostate: the style of ribbing remains the same throughout ontogeny.

Galloping: secondary ribs of one primary of one side cross the venter and are connected with two adjacent primaries on the other side (Fig. 5).

Few of the specimens described in the present publication have been collected as “ex situ” samples with their exact biostratigraphic level indeterminable. Such specimens have been excluded from the biostratigraphic discussion and have not been included in Figures 63-66.

Material with the prefix GZN is currently housed at the GeoZentrum Nordbayern of the Friedrich-Alexander-

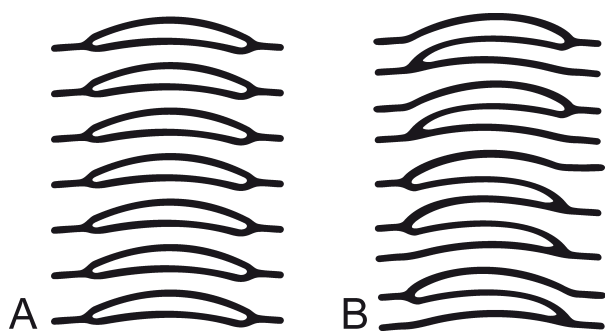


Fig. 5: Secondary ribs of a primary cross the venter and can be connected either regularly with one (A) or irregularly with two (B) primaries on the other side. In the latter case galloping of the secondary ribs occurs.

Universität Erlangen-Nürnberg, Germany, but is planned to be stored ultimately at the Department of Geology, University of Rajasthan, Jaipur, India. Specimens with the identifier OUMNH have been collected by the Late John H. CALLOMON and are kept in the collections of the Oxford University Museum of Natural History, England.

Class Cephalopoda CUVIER, 1797

Order Ammonoidea ZITTEL, 1884

Superfamily Perisphinctaceae STEINMANN, 1890

Family Perisphinctidae STEINMANN, 1890

Subfamily Perisphinctinae STEINMANN, 1890

Genus *Perisphinctes* WAAGEN, 1869

Remarks: The present study broadly adopted the classification of the genus *Perisphinctes* WAAGEN, 1869 and its subdivision into subgenera as presented by ARKELL *et al.* (1957) and modified by subsequent authors (e.g., ENAY, 1966; MALINOWSKA, 1972a, b; MÉLENDEZ, 1989; GYGI, 2000, 2001; GLOWNIAK, 2002). Although a large part of the studied collection comprises internal whorls only, most of these specimens could be assigned to their appropriate subgenus on the basis of visible morphological characters as well as the work of previous authors. In addition, the present specimens allowed further inferences on the diagnostic characteristics of the individual subgenera as described in the following.

The phenomenon of dimorphism is well known from ammonites of the genus *Perisphinctes* (e.g., CALLOMON, 1963; BROCHWICZ-LEWINSKI & ROZAK, 1976). Following this concept, it is common practice, to understand ammonite taxa as morphospecies, either representing macro- or microconch of a biospecies. Certain subgenera are generally assumed to consist of macroconchs (e.g., *Perisphinctes* s.s., *Kranaosphinctes*, *Arisphinctes*, *Liosphinctes*), while others represent microconchs (e.g., *Dichotomosphinctes*, *Dichotomoceras*; CALLOMON, 1963; GLOWNIAK & WIERZBOWSKI, 2007). As the majority of the present specimens are preserved as internal

whorls, only few of the described taxa could be reliably described as macro- or microconchs. In most instances, the present study therefore follows interpretations of previous authors.

Most recently, ROY *et al.* (2012) presented a revision of the genus *Perisphinctes* in the Oxfordian of the Kachchh Basin based on 70 ammonites, including some of the type specimens of WAAGEN (1873-1875) and SPATH (1927-1933). In this study, the authors identified all of their specimens as *Perisphinctes indogermanus* WAAGEN, 1875, thereby synonymizing a large number of species. ROY *et al.* (2012) recognized a high morphological variability in their material (even described a few distinct variants), but ascribed this to a large intraspecific variation. However, as their specimens exhibit strong morphological differences (e.g., in whorl section, ornamentation, rib density, and/or dimensions; compare ROY *et al.*, 2012, figs. 7-13) and since they have been collected from different localities and stratigraphic levels, it is more likely that they belong to several ammonite taxa.

Species of the genus *Perisphinctes* generally share a similar morphology and are occasionally very difficult to separate. It can be expected that a thorough revision of their taxonomy leads to a considerable reduction in the number of valid species (especially considering the phenomenon of dimorphism). However, a reduction to only one species covering a time span from the Early to Late Oxfordian as attempted by ROY *et al.* (2012) is exaggerated on the basis of their material and not helpful considering the use of ammonites in biostratigraphic correlations. Although synonymized by ROY *et al.* (2012), the present study therefore describes a series of species separately, due to distinct morphological differences and their occurrence in separate stratigraphic levels. Even if taxa occur in the same horizon, a continuous set of morphologically linked specimens (preferably adults with body chamber) is needed to prove that they belong to a single biospecies. If such gradual morphological changes can be seen from specimens of successive stratigraphic horizons, then this could document the evolution of a biospecies. The individual steps in this evolution might still be given different names as morphospecies (or chronospecies) to help in biostratigraphic correlations (compare DIETZE *et al.*, 2005, p. 18).

Subgenus *Perisphinctes* WAAGEN, 1869

Type species: *Ammonites variocostatus* BUCKLAND, 1836.

Remarks: Large to gigantic, whorls quadrate. Strongly variocostate; consistently fine or moderately thick ribs on inner whorls (like in *Dichotomosphinctes*) suddenly change to thick and distant ribs on outer whorls. This change may not necessarily occur on the body chamber. Peristome simple.

Perisphinctes (Perisphinctes) indogermanus

WAAGEN, 1875

Pl. I, figs. 1-4; Figs. 6, 7A, B; Tab. 2

1875c. *Perisphinctes indogermanus* WAAGEN, p. 185, pl. 47, fig. 1a-c (non pl. 48, figs. 3, 4).

1931a. *Perisphinctes indogermanus* WAAGEN. – SPATH, p. 418, pl. 68, fig. 2, pl. 98, fig. 6, pl. 99, fig. 1.

Material: Three specimens. One specimen from the southernmost tip of Khadir Island (OUMNH JY.1161). One specimen from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 073). One specimen from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 158).

Description: Shells moderately large, incomplete, septate till end, evolute, depressed, whorl section subrounded (Fig. 6A). Ornamentation on inner whorls consists of moderately thick, slightly prorsiradiate primary ribs, which exhibit a slight forward-directed concavity on the flank and branch into two moderately thick secondaries, slightly below ventrolateral region (Fig. 6B). Occasionally, branching seen in umbilicus. Secondaries cross the venter with slight forward-directed convexity. Ribbing moderately distant, with 30 to 35

primary ribs per whorl at diameters of 25 to 85 mm (Fig. 7A, B). Constrictions shallow, slightly forwardly inclined, succeeding comparatively thick primary ribs.

Remarks: The shells represent only inner whorls, but the style of ornamentation, the depressed whorl section and estimated proportional dimensions match *P. (Perisphinctes) indogermanus*. The ornamentation of the species as shown by SPATH (1931a, pl. 99, fig. 1) suggests the assignment to *Perisphinctes* s.s. The species is closely associated with taxa of the Plicatilis Zone (WAAGEN, 1875c, p. 185). *Perisphinctes* cf. *indogermanus* figured by

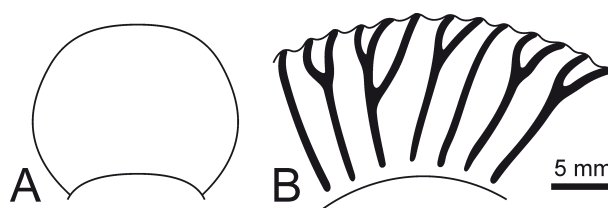


Fig. 6: *Perisphinctes (Perisphinctes) indogermanus* WAAGEN, 1875; Kantkote Ammonite Beds, Kantkote Village; GZN2010I 073. A. Whorl section at ca. 48 mm diameter. B. Ribbing pattern on right flank at ca. 45 mm diameter.

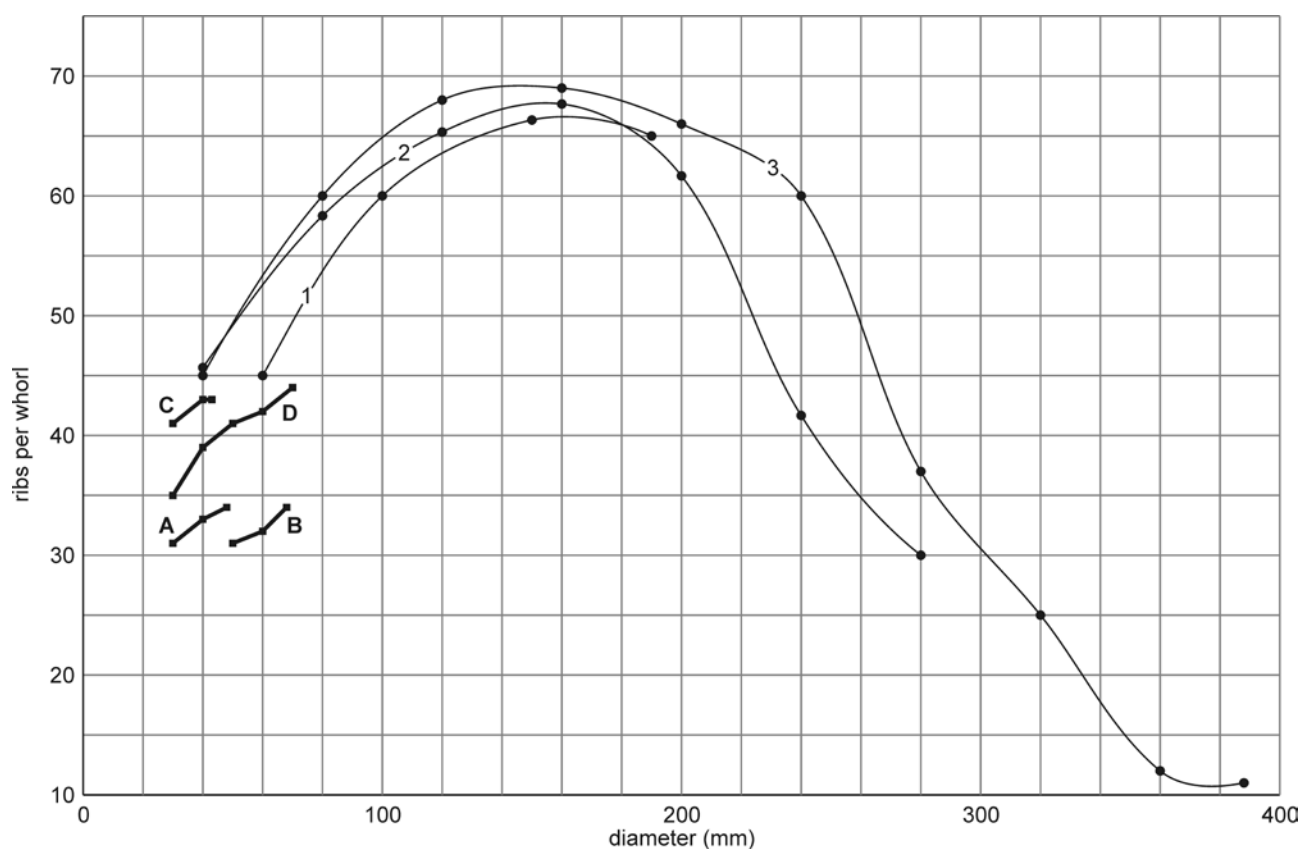


Fig. 7: A, B. Rib curves of specimens of *Perisphinctes (Perisphinctes) indogermanus* WAAGEN, 1875 from the Kachchh Basin (A: GZN2010I 073; B: GZN2010I 158). C, D. Rib curves of specimens of *Perisphinctes (Perisphinctes) martelli* (OPPEL, 1863) from the Kachchh Basin (C: GZN2010I 252; D: GZN2010I 189) compared to previously published curves of this species (1: ENAY, 1966, textfig. 104, no. 7; 2: holotype, ENAY, 1966, textfig. 104; 3: ENAY, 1966, textfig. 104, Lyon 75.107).

SPATH (1934, p. 5, pl. 5, figs. 1, 5) matches in dimensions but is very poorly preserved and therefore has not been included into the synonymy.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described the species from the Dhosa Oolite of Jara (northwest of Soorka), Keera, and Jhura domes, as well as from east of Jhuran. SPATH (1931a) mentioned the species from Jara and Keera domes, Niruna (Jhura Dome), and Lodai (Habo Dome).

***Perisphinctes (Perisphinctes) martelli* (OPPEL, 1863)**

Pl. I, figs. 5-8; Figs. 7C, D, 8; Tab. 3

1863. *Ammonites martelli* OPPEL, p. 247.
 non 1875c. *Perisphinctes martelli* (OPPEL). – WAAGEN, p. 190, pl. 55, fig. 3a, b.
 cf. 1931a. *Biplices* sp. ind. (cf. *crotalinus* DE RIAZ non SIEMIRADZKI). – SPATH, p. 424, pl. 72, fig. 7a, b.
 1966. *Perisphinctes (Perisphinctes) martelli* (OPPEL). – ENAY, p. 372, pl. 10, figs. 1-3, textfigs. 103-106.
 1998. *Perisphinctes* gr. *martelli* (OPPEL). – KRISHNA *et al.*, p. 519, pl. 1, figs. 1, 2.
 2001. *Perisphinctes (Perisphinctes)* cf. *martelli* (OPPEL). – GYGI, p. 91, figs. 138, 139.

Material: Seven specimens. Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 069, OUMNH JY.1175). Four specimens from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift (GZN2010I 152, 189, 215, 252). One stray specimen from the Tramau River, Wagad Uplift (GZN2010I 238).

Description: Shells small to moderately large, incomplete. Whorl section depressed, subquadrate in outline (Fig. 8A). Flanks convex in inner whorls, gradually becoming slightly arched and grading into rounded venter with moderately distinct ventrolateral shoulder. Ornamentation consists of sparse, moderately coarse, sharp, prorsiradial primary ribs, bifurcating into secondaries just below ventrolateral region, which cross the venter with slight forward-directed convexity (Fig. 8B). Primaries originate from the umbilical suture more or less rectiradially. Umbilical wall short, distinct. Up to four weak constrictions per whorls (only on the inner whorls).

Remarks: The specimens match *Perisphinctes (Perisphinctes) martelli* (OPPEL, 1863). Their ribbing density is moderate, increases gradually during early ontogeny, and compares well with previous descriptions (Fig. 7C, D). In the present study only depressed forms have been included in this species. Specimens identified as *Perisphinctes martelli* (OPPEL) by WAAGEN (1875c) are compressed and therefore have been excluded from the synonymy list.

The suture lines are not always well preserved. The last suture line visible in specimen GZN2010I 238 is at a diameter of about 83 mm. Constrictions are not well developed, at times bifurcation of primary ribs close to

the umbilical suture can be observed on inner whorls. The following inter-rib area appears slightly deeper, as in the case of constrictions. There are, however, no traces of constrictions on the venter of the outer whorls. There is a tendency of the ribs to become more rectiradial on the outer whorls. This feature, together with the sharp, regularly bifurcating ribs and the absence of distinct constrictions, match the characters of *Dichotomoceras* (ARKELL, 1935, pp. xv, xxx, xxxix, pl. B, fig. 4; 1936, p. xxxvii; ARKELL *et al.*, 1957, p. L322). *Dichotomoceras predivisum* SPATH (1931a, p. 422, pl. 97, fig. 2, pl. 98, fig. 2) and *Perisphinctes (Dichotomoceras) crassus* (ENAY, 1966, p. 507, pl. 33, fig. 8, pl. 34, fig. 5) have similar whorl section but are more coarsely ribbed and rather tightly coiled. The coiling and ornamentation of *Perisphinctes* gr. *martelli* (OPPEL) recorded by KRISHNA *et al.* (1998, p. 519, pl. 1, figs. 1, 2) match those of the present specimens. The ornamentation and proportional dimensions of specimen GZN2009II 207 from the Dhosa Conglomerate Bed east of Rudra Mata, is also similar to the Middle Oxfordian *Dichotomosphinctes* aff. *luciae* (DE RIAZ) from Europe (SPATH, 1931a, p. 439, pl. 72, fig. 6a, b, pl. 77, fig. 2).

Earlier records from the Kachchh Basin: KRISHNA *et al.* (1998) described the species from Kantkote (Wagad Uplift).

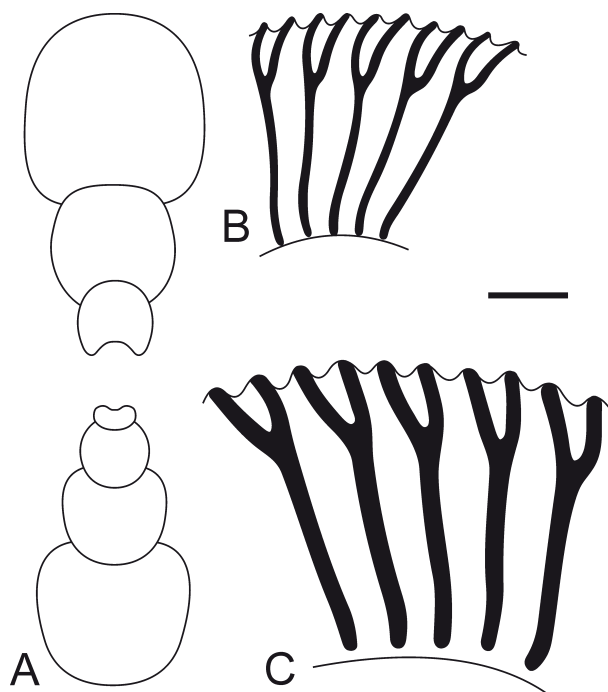


Fig. 8. *Perisphinctes (Perisphinctes) martelli* (OPPEL, 1863); Kantkote Ammonite Beds, Tramau River. A. Cross section (scale bar = 10 mm); GZN2010I 238. B. Ribbing pattern on right flank at ca. 43 mm diameter (scale bar = 5 mm); GZN2010I 252. C. Ribbing pattern on left flank at ca. 71 mm diameter (scale bar = 5 mm); GZN2010I 189.

Perisphinctes (Perisphinctes) sp.

Pl. I, fig. 9

Material: One fragment of a body whorl from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 134).

Description: Small fragment of the body chamber of an evolute shell with large umbilical diameter, compressed whorl section with high whorl height and slightly arched flanks. Ornamentation on body chamber consists of thick, distant folds, the folds being thickest near the ventrolateral shoulder and gradually fade towards the mid-ventral region. Folds show a slight forward-directed concavity and have a slightly steeper slope towards the aperture. Umbilical wall short and vertical.

Remarks: In the Trama River no similar body chamber has been recorded. Related Middle Oxfordian forms with comparable body chambers are known from regions outside Kachchh, e.g., *Perisphinctes (Perisphinctes) pumilus* ENAY (1966, p. 350, pl. 4, fig. 3b) and *Decipia gr. gigantoplex* (QUENSTEDT) (ENAY, 1966, p. 564, pl. 38, fig. 3a) from Europe. In the latter species the whorl height at this diameter is smaller. KRISHNA *et al.* (2009b, p. 475, pl. 1, fig. 3) recorded and figured a similar specimen from the Rotoides Subzone of the late Middle Oxfordian Transversarium Zone (not Bifurcatus Zone of the early Late Oxfordian as mentioned in the figure caption by KRISHNA *et al.*, 2009b) of Kantkote as *Perisphinctes cf. strumatus* (BUCKMAN). From the figure of *Perisphinctes (Perisphinctes) strumatus* given by ENAY (1966, pl. 14, fig. 1a) it seems that the ribs terminate at the ventrolateral shoulder (compare also BUCKMAN, 1927, vol. 7, pl. 747, figs. A-D), which is not the case in the present specimen. Due to the fragmentary state of preservation it should be assigned to *Perisphinctes* without any further identification.

Subgenus *Kranaosphinctes* BUCKMAN, 1921

Type species: *Kranaosphinctes kranaus* BUCKMAN, 1921.

Remarks: Large to gigantic in size, evolute, inflated, whorl section rounded to depressed, ribbing changing gradually from moderately thick to coarse (gradually vario- to varicostate) with the venter becoming smooth before septation ceases. Deep constrictions and a simple peristome.

***Perisphinctes (Kranaosphinctes) nerunaensis*
(SPATH, 1931)**

Pl. II, figs. 1-3; Pl. III, figs. 1-4; Figs. 9, 10; Tab. 4

1931a. *Pachyplanulites nerunaensis* SPATH, p. 430, pl. 96, fig. 5.

1931a. *Perisphinctes colei* SPATH, p. 421, pl. 96, fig. 2 (non pl. 80, fig. 2a, b).

1931a. *Perisphinctes kheraensis* SPATH, p. 420, pl. 95, fig. 3 (non pl. 74, fig. 5a, b).

1959b. *Kranaosphinctes (Pachyplanulites) nerunaensis* SPATH.
– COLLIGNON, pl. 75, fig. 312.

Material: Sixteen specimens. Five specimens from the Dhosa Oolite (GZN2010I 1089, OUMNH JY.348, JY.526, JY.527, JY.528), two specimens from reworked, concretionary slabs floating in the Dhosa Conglomerate Bed (GZN2009II 025, 196), and five specimens from the Dhosa Conglomerate Bed (GZN2009II 006, 007, 071, 198, GZN2010I 1085) of the Jara Dome. One specimen from a reworked, concretionary slab floating in the Dhosa Conglomerate Bed (GZN2009II 197), and two specimens from the Dhosa Conglomerate Bed (GZN2009II 164, 211) close to Medisar, Jhura Dome. One specimen from the southernmost tip of Khadir Island (OUMNH JY.1160).

Description: Shells small to moderately large, incomplete, septate till end, evolute, inner whorls depressed, outer whorls becoming less depressed. Whorl section subquadrangular, flanks slightly convex (inner whorls) to flat, merging into slightly arched venter (Fig. 9A-F). Umbilical wall indistinct. Ornamentation consists of very gradually varicostate, moderately coarse, sharp, and moderately spaced primary ribs, originating near the umbilical suture with rursiradiate orientation then turn prorsiradiate near the umbilical margin. Primaries branch regularly into two finer secondaries at the ventrolateral shoulder and cross the venter with slight forward-directed convexity (Fig. 9H, I). Ribbing density is moderate, increasing during growth before a plateau is reached at a diameter of 90 mm with about 49 ribs per whorl (Fig. 10). Venter smooth on outer whorl. Constrictions deep, slightly inclined, numbering at least two per whorl.

Remarks: The proportional dimensions of the present specimens are similar to *P. (Kranaosphinctes) nerunaensis* except for being slightly less evolute than those recorded by SPATH (1931a). The general morphological characters such as the ribbing pattern and the wide umbilicus are also similar to *Perisphinctes aberrans* WAAGEN (1875c, p. 175, pl. 41, figs. 1a-c, 2a-c), but the ratio between whorl height and thickness is less in the present specimens. Furthermore, *Perisphinctes aberrans* has compressed inner whorls. The style of ornamentation is somewhat close to *Subgrossouvria?* sp. ind. (SPATH, 1931a, p. 382, pl. 68, fig. 1) but in the present specimens the flanks of the outer whorls are flatter.

Although in none of the specimens the body chamber is preserved we still assign them to the subgenus *Kranaosphinctes*, because of the depressed whorl section, moderately thick, varicostate ornamentation, smooth venter of the outer whorl and deep constrictions. Two specimens described from Niruna (Jhura Dome) by SPATH (1931a) as *Perisphinctes kheraensis* (pl. 95, fig. 3) and *Perisphinctes colei* (pl. 96, fig. 2) have been included in the present species due to their depressed whorl section, as well as a style of ribbing typical for *Kranaosphinctes*.

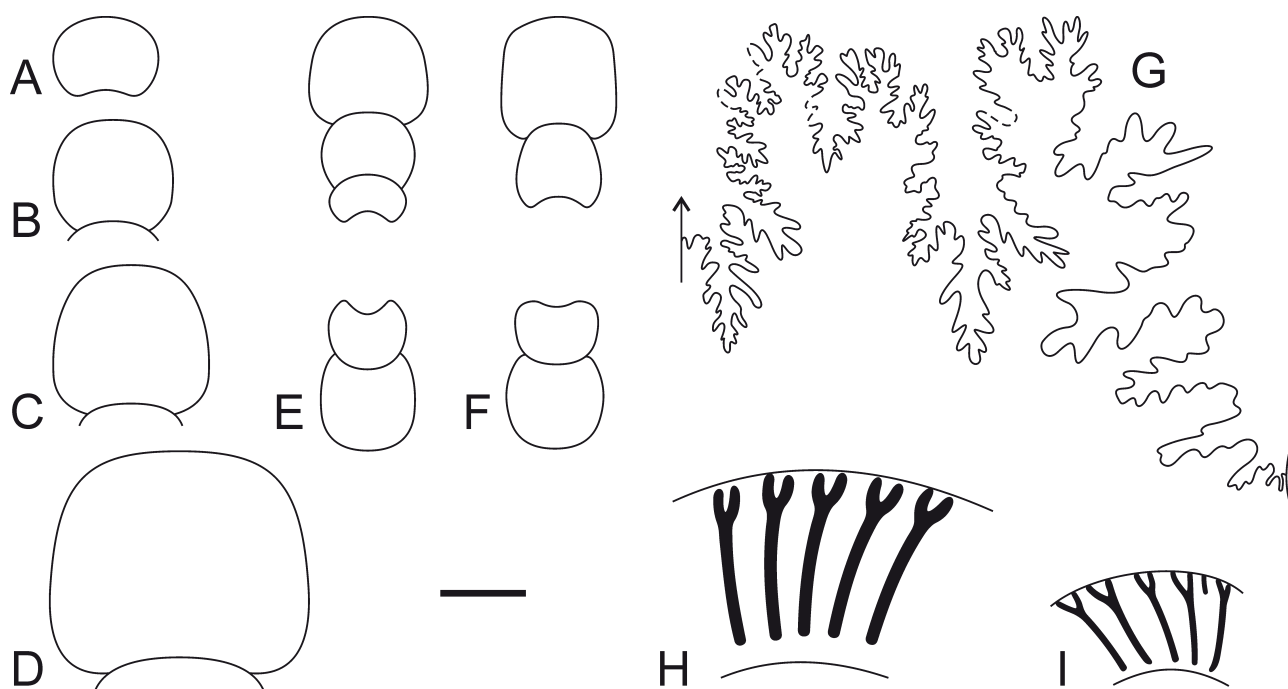


Fig. 9: *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* (SPATH, 1931). A. Whorl section at unknown diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2010I 1085. B. Whorl section at unknown diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Medisar, Jhura Dome; GZN2009II 211. C. Whorl section at ca. 68 mm diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 007. D. Whorl section at ca. 110 mm diameter (scale bar = 10 mm); slab in Dhosa Conglomerate Bed, Jara Dome; GZN2009II 025. E. Cross section (scale bar = 10 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 071. F. Cross section (scale bar = 10 mm); slab in Dhosa Conglomerate Bed, Jara Dome; GZN2009II 196. G. Suture line at ca. 105 mm diameter (scale bar = 5 mm); slab in Dhosa Conglomerate Bed, Jara Dome; GZN2009II 025. H. Ribbing pattern on right flank at ca. 85 mm diameter (scale bar = 10 mm); slab in Dhosa Conglomerate Bed, Jara Dome; GZN2009II 025. I. Ribbing pattern on left flank at ca. 40 mm diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 006.

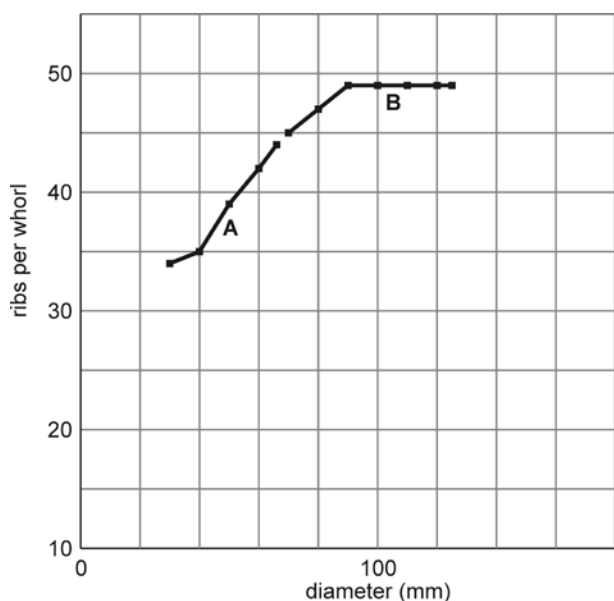


Fig. 10: Rib curves of specimens of *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* (SPATH, 1931) from the Kachchh Basin (A: GZN2009II 164; B: OUMNH JY.348).

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite close to Niruna (Jhura Dome).

***Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875
Pl. III, figs. 5, 6; Pl. IV, figs. 1-6; Figs. 11, 12A; Tab. 5**

1875c. *Perisphinctes pagri* WAAGEN, p. 181, 42, fig. 2a-c.
1931a. *Pachyplanulites pagri* (WAAGEN). – SPATH, p. 431.

Material: Eleven specimens. Ten specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 081, 084, 087, 090, 096, 119, 133, GZN2011I 339, OUMNH JY.1178, JY.1168). One stray specimen from the Trama River, Wagad Uplift (GZN2010I 236).

Description: Shell small to moderately large, incomplete, septate till end, evolute and depressed. Whorl section subcircular with moderately to acutely rounded flanks merging smoothly into wide, slightly arched venter (Fig. 11A-E). Umbilical wall short, moderately distinct, steeply inclined. Ornamentation consists of varicostate, moderately thick, sharp primary ribs, numbering about 40 per whorl (Fig. 12A) and originating near the umbilical

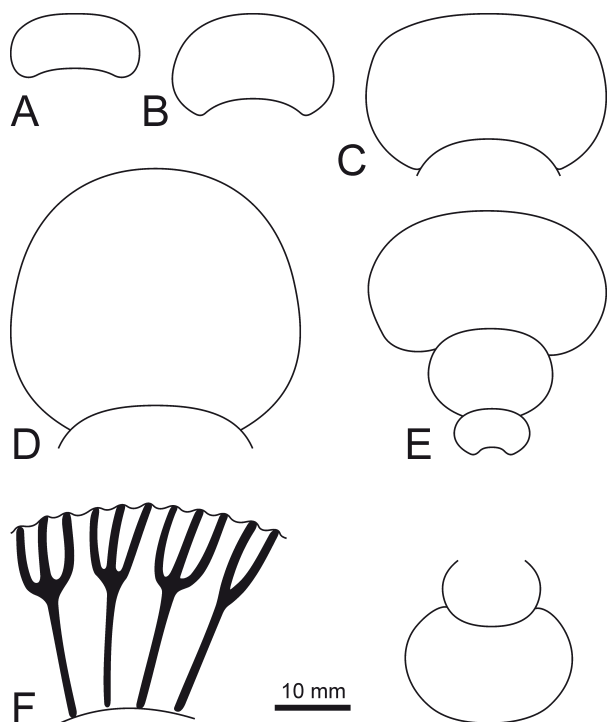


Fig. 11: *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875; Kantkote Ammonite Beds, Kantkote Village. A. Whorl section at unknown diameter; GZN2010I 133. B. Whorl section at unknown diameter; GZN2010I 084. C. Whorl section at unknown diameter; GZN2010I 084. D. Whorl section at unknown diameter; GZN2010I 081. E. Cross section; GZN2010I 087. F. Ribbing pattern on right flank at ca. 102 mm diameter; GZN2010I 096.

suture or the middle of the umbilical wall with more or less rectiradiate orientation and becoming very slightly prorsiradiate around the umbilical margin. Primaries branch regularly into two or three finer secondaries at the ventrolateral region (Fig. 11F). They cross the venter either straight or with slight forward or backward directed convexity. Such convexity is more common on outer whorls. Constrictions distinct, more strongly inclined towards the aperture than the ribs (forming an angle of around 20° with primary ribs), numbering at least two per whorl.

Remarks: The specimens show much variability in the ratio of whorl height to whorl width even at similar diameters. Nevertheless, they all fall within a range of variation forming a continuous series. *Perisphinctes* (*Kranaosphinctes*) *subevolutus* WAAGEN (described below) is a closely related species, from which the present specimens can be differentiated on the basis of a more depressed whorl section, a wider venter, narrower umbilicus, and sparser primary ribs which trifurcate more often. According to SPATH (1931a, p. 431) *P. (K.) subevolutus* WAAGEN is “possibly of earlier age, [and] may belong to the ancestral stock that produced the present form”. For the stratigraphic

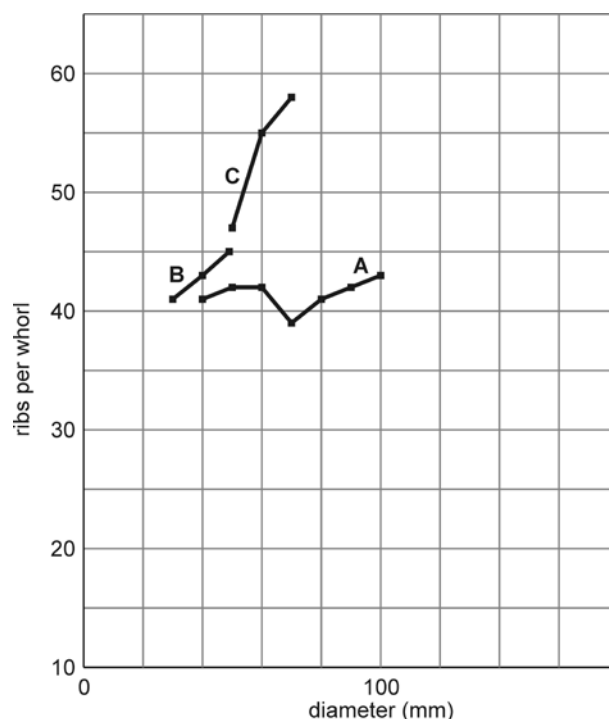


Fig. 12: A. Rib curve of *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875 from the Kachchh Basin (GZN2010I 090). B, C. Rib curves of specimens of *Perisphinctes* (*Kranaosphinctes*) *subevolutus* WAAGEN, 1875 from the Kachchh Basin (B: GZN2009II 012; C: GZN2010I 067).

distribution of these two species see Figures 63-66. COLLIGNON (1959b, pl. 75, fig. 313) differentiated *Kranaosphinctes* (*Pachyplanulites*) *praeevolus* (*Dichotomosphinctes wartae-Proscaphites anar* Zone of Madagascar) from *P. (K.) subevolutus* WAAGEN on the basis of a more compressed whorl and less prorsiradiate ribbing. However, as has been mentioned above, the ratio of whorl height to whorl width shows a high intraspecific variability. The degree of forward inclination of primary ribs is also not adequately different to warrant an independent taxonomic status. Similarly, *Kranaosphinctes* (*Pachyplanulites*) *roedereri* recorded by COLLIGNON (1959b, pl. 72, fig. 307) from the same stratigraphic level as *Kranaosphinctes* (*Pachyplanulites*) *praeevolus* does not show much difference to justify an independent taxonomic status. However, the number of ribs per whorl in these species differ from that of *pagri* (47 in *praeevolus* and 32 in *roedereri*).

Specimen GZN2010I 236 is a large, but poorly preserved specimen collected loose from the Trama River section. However, in general shell morphology it matches *pagri* very well.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described the species from the Kantkote Sandstone (Wagad Uplift) as well as from Gangta Bet. SPATH (1931a) mentioned the species from the Kantkote Sandstone (Wagad Uplift).

Perisphinctes (Kranaosphinctes) subevolutus

WAAGEN, 1875

Pl. V, figs. 1-11; Figs. 12B, C, 13; Tab. 6

1875c. *Perisphinctes subevolutus* WAAGEN, p. 179, pl. 45, fig. 3a, b (holotype).

1931a. *Pachyplanulites subevolutus* (WAAGEN). – SPATH, p. 428, pl. 52, fig. 4a, b, pl. 62, fig. 2a, b, pl. 65, fig. 6.

1959b. *Kranaosphinctes (Pachyplanulites) subevolutus* WAAGEN. – COLLIGNON, pl. 89, figs. 352, 353.

Material: Forty-five specimens. Two specimens from the Dhosa Oolite (GZN2009II 165, OUMNH JY.532) and thirteen specimens from the Dhosa Conglomerate Bed (GZN2009II 001, 008, 012, 026, 070, 072, 210, 233-235, 238, GZN2010I 1083, OUMNH JY.529) of the Jara Dome. Four specimens from the Dhosa Conglomerate Bed of the Jumara Dome (GZN2009II 014, 068, 069, 208). One specimen from the Dhosa Conglomerate Bed close to Medisar, Jhura Dome (GZN2009II 209). Four specimens from the Dhosa Oolite (GZN2009II 077, 078, OUMNH JY.830, JY.884) and one specimen from the Dhosa Conglomerate Bed (GZN2009II 009) close

to Jhura Camp, Jhura Dome. One specimen from a thin layer of Dhosa Oolite on top of the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome (GZN2010I 1097). Nine specimens from the Dhosa Conglomerate Bed at Ler, southeast of Bhuj (GZN2009II 246, GZN2010I 1018-1023, 1029, 1030). Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 067, 071). Five specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 155, 175, 203, 210, 244). Three stray specimens from the Trama River, Wagad Uplift (GZN2010I 227, 237, 240).

Description: Shells small, incomplete, septate till end, evolute, depressed. Whorl section subcircular, with rounded flanks grading smoothly into moderately arched venter (Fig. 13A-G). Umbilical wall short, moderately distinct, steeply inclined. Ornamentation consists of moderately thick, varicostate, primary ribs originating near the umbilical suture or at the middle of the umbilical wall with rectiradial orientation, turning prorsiradial near the umbilical margin. Primaries branch into two, rarely three, finer secondaries at the ventrolateral region

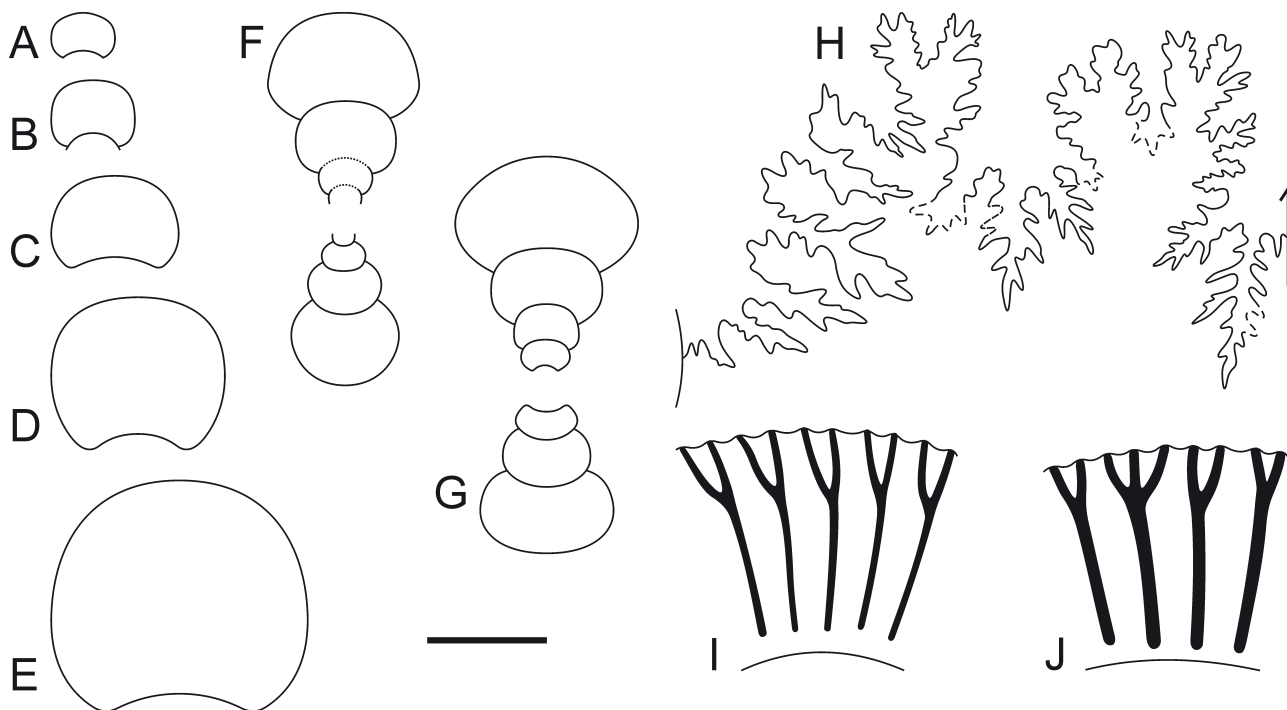


Fig. 13: *Perisphinctes (Kranaosphinctes) subevolutus* WAAGEN, 1875. A. Whorl section at ca. 19 mm diameter (scale bar = 15 mm); Dhosa Conglomerate Bed, Ler; GZN2010I 1023. B. Whorl section at ca. 21 mm diameter (scale bar = 15 mm); Kantkote Ammonite Beds, Kantkote Village; GZN2010I 071. C. Whorl section at unknown diameter (scale bar = 15 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 235. D. Whorl section at unknown diameter (scale bar = 15 mm); thin layer of Dhosa Oolite on top of the Dhosa Conglomerate Bed, Rudra Mata, Habo Dome; GZN2010I 1097. E. Whorl section at unknown diameter (scale bar = 15 mm); Dhosa Conglomerate Bed, Jumara Dome; GZN2009II 208. F. Cross section (scale bar = 15 mm); Kantkote Ammonite Beds, Trama River; GZN2010I 244. G. Cross section (scale bar = 15 mm); Kantkote Ammonite Beds, Trama River; GZN2010I 210. H. Suture line at ca. 16 mm whorl height (scale bar = 5 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 070. I. Ribbing pattern on left flank at ca. 45 mm diameter (scale bar = 7.5 mm); Trama River; GZN2010I 237. J. Ribbing pattern on right flank at unknown diameter (scale bar = 15 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 208.

(Fig. 13I, J), with occasionally the third secondary rib being free. Secondaries cross the venter either straight (inner whorls) or with slight forward-directed convexity (outer whorls). Ribbing density is moderate to high, increasing during ontogeny (Fig. 12B, C). Constrictions distinct, forwardly inclined, numbering three per whorl.

Remarks: These are inner whorls of moderately large perisphinctids. The large number of different-sized specimens enabled the measurement of the ratio between whorl height and thickness at different diameters. This ratio shows much variability. Similar observations can be made from the proportional dimensions given by WAAGEN (1875c, p. 179) and SPATH (1931a, p. 428) for this species. The depressed whorl section and the varicostate, moderately thick primaries match *Kranaosphinctes*. The proportional dimensions and ornamentation of the present specimens also match *Subgrossouvria morleydaviesi* SPATH (1931a, p. 376, pl. 45, fig. 6a, b, pl. 59, figs. 4, 5) from the Callovian. Due to the arched flanks, only primary ribs are visible in the lateral view of some specimens (e.g. GZN2009II 014). Such arched flanks and the ornamentation of the present specimens also match *Properisphinctes bernensis* (DE LORIO) (SPATH, 1931a, p. 404, pl. 54, figs. 3a, b, 9a, b, pl. 58, fig. 8, pl. 59, fig. 7). *Passendorferia* (*Enayites*) aff. *gygii* BROCHWICZ-LEWINSKI & ROZAK (CECCA & SAVARY, 2007, p. 523, fig. 7e) shows comparable proportionate dimensions, ornamentation, and whorl section.

The ornamentation of specimen GZN2009II 077 also matches *Subgrossouvria?* sp. ind. (SPATH, 1931a, p. 382, pl. 68, fig. 1). The proportional dimensions are also similar except that this specimen is more evolute than recorded by SPATH (1931a). The forwardly inclined ribs are similar to *Subgrossouvria blakei* SPATH (1931a, p. 374, pl. 65, fig. 5a, b), but no information is available of the rib density on the inner whorls of this species, which appears to be less than in all other species of *Subgrossouvria* recoded from Kachchh.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described the species from the Dhosa Oolite of Jara (northwest of Soorka) and Jhura domes. SPATH (1931a) mentioned the species from the Dhosa Oolite of Jumara and Keera domes as well as from a river bed west of Kantkote.

Subgenus *Arisphinctes* BUCKMAN, 1924

Type species: *Arisphinctes ariprepes* BUCKMAN, 1924.

Remarks: Large to gigantic in size, evolute, whorl quadrate or rounded-quadrate, ribbing changing gradually from fine to intermediate (gradually vari- to variocostate). Secondary ribs very fine; venter turns smooth before septation ceases. Constrictions present, peristome simple.

GLOWNIAK (2002) included the subgenus *Arisphinctes* in the synonymy of *Kranaosphinctes* due to only

minor differences between both forms. As complete adult specimens of these subgenera are very rare in the Kachchh Basin, a comprehensive reevaluation of both subgenera is not possible at the moment. In the present study, the traditional division is therefore retained, separating *Arisphinctes* from *Kranaosphinctes* mainly by their different ribbing densities (compare also ENAY, 2009).

Perisphinctes (*Arisphinctes*) sp. cf.

Perisphinctes calvus (J. DE C. SOWERBY, 1840)

Pl. VI, figs. 1-3; Fig. 14; Tab. 7

cf. 1840. *Ammonites calvus* J. DE C. SOWERBY, pl. 61, fig. 9.
cf. 1875c. *Perisphinctes calvus* (J. DE C. SOWERBY). –
WAAGEN, p. 166, pl. 56, fig. 1a, b.

Material: Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 106, 127).

Description: Shell moderately large, incomplete, evolute, compressed. Whorl section suboval with arched flanks with sloping umbilical wall and indistinct umbilical margin. Maximum thickness of whorl near the umbilical margin (Fig. 14). Ornamentation consists of thick, distant, prorsiradiate, forwardly concave primary ribs, branching into three to four finer secondaries at umbilical suture, which cross the venter with faint forward-directed convexity. Primaries become stronger and venter becomes smooth on the outer whorls.

Remarks: These are fragmentary specimens representing the outer and part of an inner whorl. Ornamentation and whorl section match *Perisphinctes calvus* described by WAAGEN (1875c). SPATH (1931a, p. 331, pl. 52, fig. 1) recorded similar forms from Middle Callovian rocks in the Keera Dome and designated *calvus*, described and illustrated by WAAGEN (1875c), as the type species of

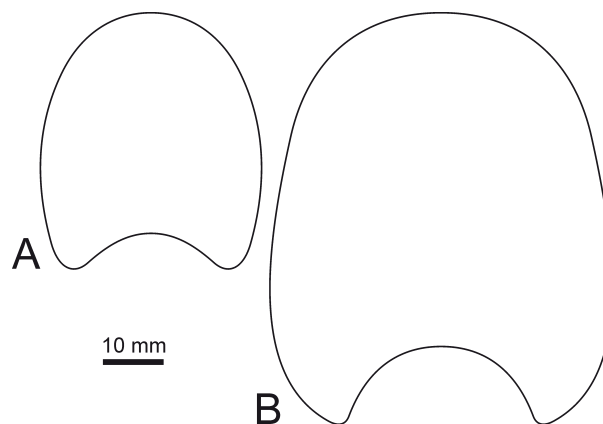


Fig. 14: *Perisphinctes* (*Arisphinctes*) sp. cf. *Perisphinctes calvus* (J. DE C. SOWERBY, 1840); Kantkote Ammonite Beds, Kantkote Village; GZN2010I 127. A. Whorl section at unknown diameter. B. Whorl section at unknown diameter.

his new genus *Indosphinctes*. The characteristic features of *Indosphinctes* such as “inconspicuous primary ribs, often bundled or confined to a blunt node at the umbilical edge” (COX, 1988, p. 21) and a distinct umbilical margin neither match the description and illustration by WAAGEN (1875c), nor the present specimens. WAAGEN (1875c) considered the holotype of J. DE C. SOWERBY to have been collected from the Oxfordian of Kachchh, whereas SPATH (1931a) considered it to be from the Callovian. However, the original locality from which the holotype has been collected is unknown. Both forms, together with *Perisphinctes balinensis* NEUMAYR from the Lower Callovian of Kachchh (WAAGEN, 1875c, p. 163), might be homeomorphs.

Earlier records from the Kachchh Basin: The exact locality and stratigraphic level of the species described by WAAGEN (1875c) is doubtful. WAAGEN (1875c) mentions its source as either the Kantkote Sandstone or the Dhosa Oolite on the road to Rapar (northeastern Wagad Uplift). Since the Dhosa Oolite does not occur in the Wagad Uplift, it seems most likely that WAAGEN’s (1875c) specimen originated from the Kantkote Sandstone.

***Perisphinctes (Arisphinctes) chloroolithicus*
(GÜMBEL, 1865)**

Pl. VII, figs. 3-7; Figs. 15, 16; Tab. 8

- non 1875c. *Perisphinctes chloroolithicus* GÜMBEL. – WAAGEN, p. 198, pl. 50, fig. 3a, b (compare SPATH, 1931a, p. 455).
1938. *Perisphinctes (Perisphinctes) chloroolithicus* (GÜMBEL). – ARKELL, p. 95; pl. 18, figs. 1-7, pl. 19, fig. 4, textfigs. 24-27.
- cf. 1966. *Perisphinctes (Perisphinctes)* cf. *chloroolithicus* (GÜMBEL). – ENAY, p. 363, pl. 5, fig. 4, textfigs. 95, 101.
2001. *Perisphinctes (Perisphinctes) chloroolithicus* (GÜMBEL). – GYGI, p. 60, figs. 89-91.

Material: Nineteen specimens. Five specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 074, 076, 080, 083, 093). Thirteen specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 156, 157, 161, 163, 172, 177, 183, 185, 186, 199, 204, 206, 213). One stray specimen with unknown locality (GZN2010I 260).

Description: Shells small to moderately large, incomplete, septate till end, evolute, compressed. Whorl section subquadrate to subtabulate in outline, flanks flat, merging smoothly into rounded venter (Fig. 15A-D). Ornamentation consists of gradually varicostate, sharp, prorsiradiate primary ribs, very fine in nucleus and moderately coarse in middle whorls. Primaries generally bifurcate into finer secondary ribs at ventrolateral region. Bifurcation occasionally also seen in umbilicus. Secondary ribs cross the venter with slight forward-directed convexity. Ribs originate rursiradiately

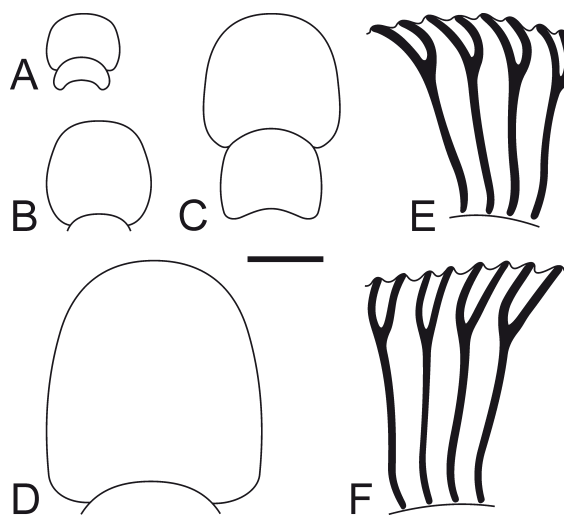


Fig. 15: *Perisphinctes (Arisphinctes) chloroolithicus* (GÜMBEL, 1865); Kantkote Ammonite Beds, Kantkote Village (A-C) and Trama River (D-F). A. Whorl sections at unknown diameter (scale bar = 10 mm); GZN2010I 080. B. Whorl section at ca. 52 mm diameter (scale bar = 10 mm); GZN2010I 083. C. Cross section at ca. 66 mm diameter (scale bar = 10 mm); GZN2010I 093. D. Whorl section at ca. 123 mm diameter (scale bar = 10 mm); GZN2010I 183. E. Ribbing pattern on left flank at ca. 41 mm diameter (scale bar = 5 mm); GZN2010I 185. F. Ribbing pattern on right flank at ca. 117 mm diameter (scale bar = 10 mm); GZN2010I 183.

at umbilical suture (Fig. 15E, F). Ribbing density is moderate to dense. Umbilical wall short, distinct, and steep. Constrictions present, at least one per whorl.

Remarks: In the present study, *Perisphinctes chloroolithicus* (GÜMBEL, 1865) has been assigned to the subgenus *Arisphinctes*, because it exhibits a gradually varicostate ornamentation and finer secondary ribs than *Perisphinctes* s.s. The inner whorls of *Perisphinctes* s.s. are ornamented by consistently fine primary ribs (similar to *Dichotomosphinctes*), but on the outer whorl a sudden change to distant ribs can be seen. In *Arisphinctes*, the nucleus has very fine ribs, which are gradually changing into more sparse, coarser ribs in the middle whorls, as in the present species.

One of the best preserved specimens (GZN2010I 183) seems to have been broken just behind the last septum (at a diameter of 122 mm). However, *P. (Arisphinctes) chloroolithicus* is septate until a diameter ranging from 232 to 335 mm. This specimen might therefore represent a juvenile. The rib curves constructed for the present material match previously published graphs of this species (Fig. 16). The proportional dimensions of the specimens are also similar to those of *Perisphinctes (Dichotomoceras) bifurcatus* QUENSTEDT described and illustrated by ENAY (1966, p. 504, pl. 33, figs. 1-7). In the latter species the ornamentation is, however,

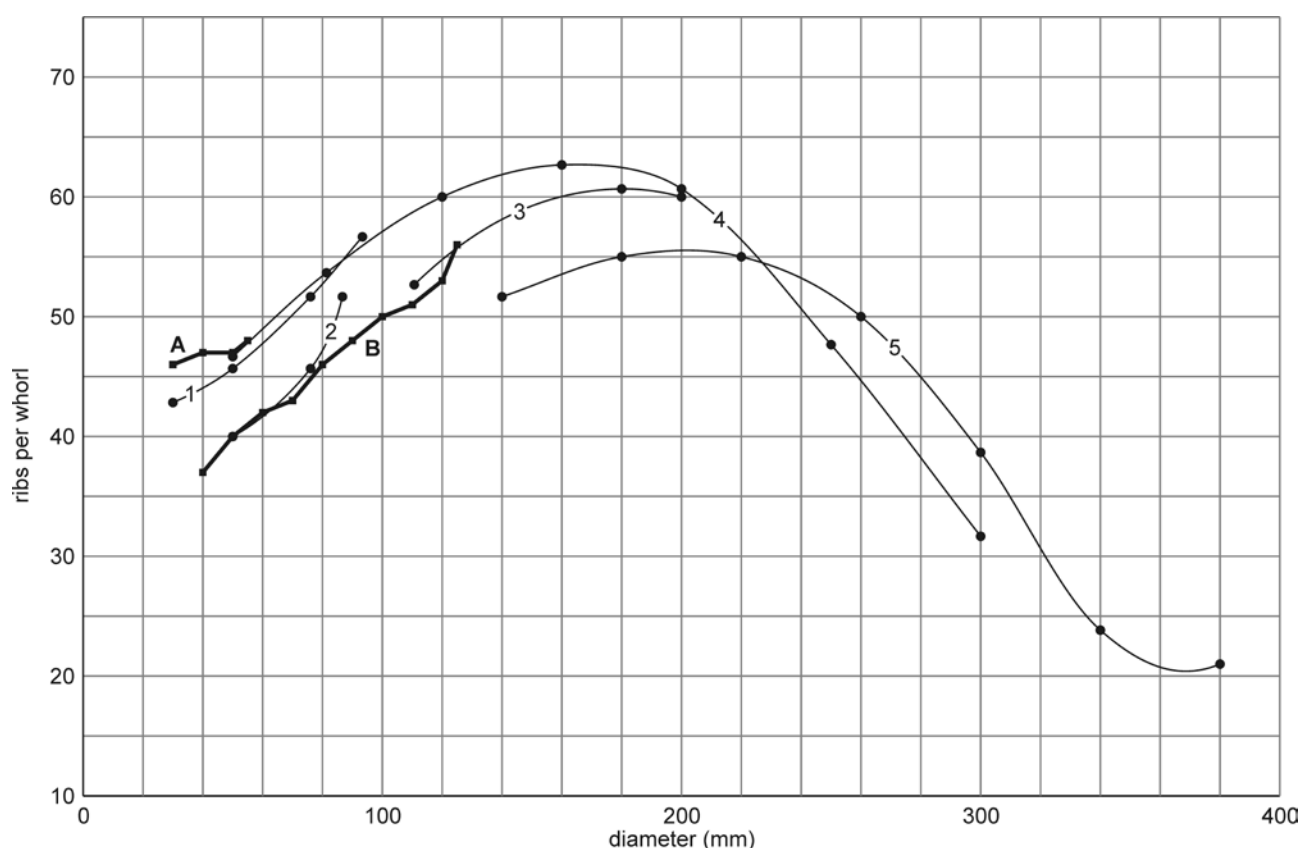


Fig. 16: Rib curves of specimens of *Perisphinctes* (*Arisphinctes*) *chloroolithicus* (GÜMBEL, 1865) from the Kachchh Basin (A: GZN2010I 157; B: GZN2010I 183) compared to previously published curves of this species (1: specimen figured by DORN, 1930, pl. IV, fig. 1, modified from ENAY, 1966, textfig. 101; 2: holotype, figured by DORN, 1930, pl. IV, fig. 2, modified from ENAY, 1966, textfig. 101; 3: ARKELL, 1939, textfig. 24, no. 3; 4, 5: ENAY, 1966, textfig. 101, no. 4, 1).

coarser and less dense than in the present specimens. *Dichotomosphinctes falculae* (RONCHADZÉ) (SPATH, 1931a, p. 435, pl. 68, fig. 7) also seems to be closely related but can be differentiated on the basis of its smaller size and tighter coiling. The present specimens are compressed and the ornamentation in the middle whorl is slightly coarser than in *Perisphinctes* (*Perisphinctes*) *martelli* described above. The ventrolateral shoulder is more distinct in *martelli* than in the present specimens. The sharp primaries on inner whorls and the occasional point of bifurcation seen in the umbilicus are comparable to *Perisphinctes* (*Arisphinctes*) *kachchhensis* sp. nov. as described below, but this species is depressed at comparable whorl height.

***Perisphinctes* (*Arisphinctes*) cf. *colei* SPATH, 1931
Pl. VI, fig. 4, 6; Figs. 17, 18; Tab. 9**

cf. 1931a. *Perisphinctes colei* SPATH, p. 421, pl. 80, fig. 2a, b (holotype) (non pl. 96, fig. 2).

Material: Seven specimens. Three specimens from reworked, concretionary slabs floating in the Dhosa

Conglomerate Bed (GZN2010I 1068, 1069, 1071) and one specimen from the Dhosa Conglomerate Bed (GZN2009II 203) of the Jara Dome. One specimen from the Dhosa Oolite of the Jumara Dome (GZN2009II 191). One specimen from a thin layer of Dhosa Oolite on top of the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome (GZN2009II 027). One specimen from the Dhosa Conglomerate Bed at Ler, southeast of Bhuj (GZN2010I 1004).

Description: Shells large, incomplete, septate till end, evolute. Innermost whorls slightly depressed, outer ones compressed. Whorl section subtrigonal to ovate, attaining its maximum thickness slightly above the umbilical margin (Fig. 17A-E). Flanks more or less flat, merging smoothly into moderately convex venter. Ornamentation consists of gradually varicostate, sharp, prorsiradiate, and forwardly concave primary ribs originating on the umbilical wall with rursiradiate orientation up to the umbilical margin. Primaries branch into two finer, slightly rounded secondaries at the lower part of the ventrolateral region. They cross the venter with forward-directed convexity. Primaries become thicker with growth. Ribbing density increases distinctly

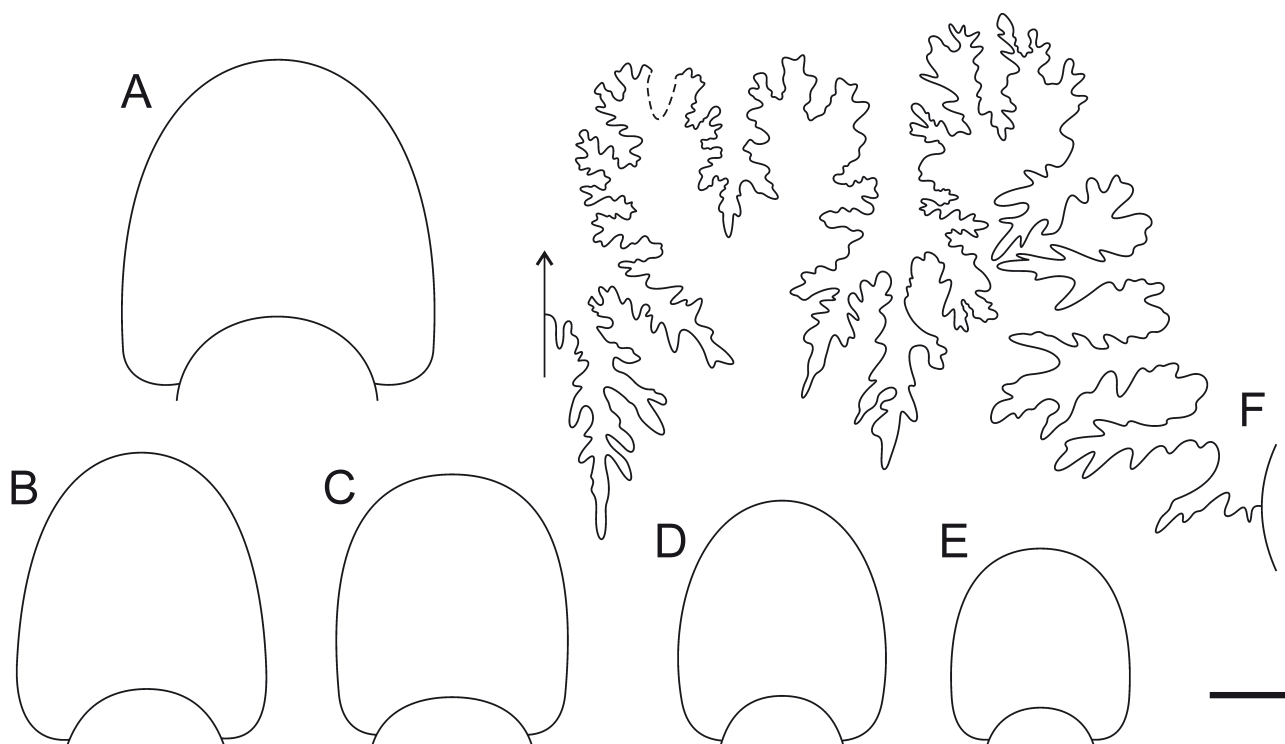


Fig. 17: *Perisphinctes (Arisphinctes) cf. colei* SPATH, 1931; slab in Dhosa Conglomerate Bed (A-C, E) and Dhosa Conglomerate Bed (D, F), Jara Dome. A. Whorl section at unknown diameter (scale bar = 10 mm); GZN2010I 1071. B. Whorl section at unknown diameter (scale bar = 10 mm); GZN2010I 1068. C. Whorl section at unknown diameter (scale bar = 10 mm); GZN2010I 1069. D. Whorl section at unknown diameter (scale bar = 10 mm); GZN2009II 203. E. Whorl section at unknown diameter (scale bar = 10 mm); GZN2010I 1068. F. Suture line at ca. 26 mm whorl height (scale bar = 4 mm); GZN2009II 203.

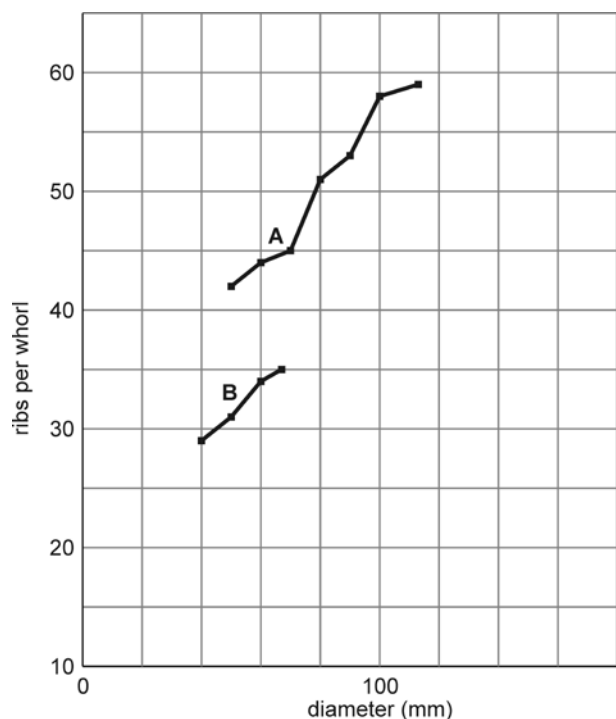


Fig. 18: Rib curves of specimens of *Perisphinctes (Arisphinctes) cf. colei* SPATH, 1931 from the Kachchh Basin (A: GZN2009II 027; B: GZN2009II 191).

from diameters 50 to 120 mm (Fig. 18). Umbilical wall indistinct, short. Constrictions distinct, slightly oblique, three per whorl.

Remarks: The specimens resemble *Perisphinctes (Perisphinctes) indogermanus* (WAAGEN) in general style of ribbing, but the ribs are finer and more dense (WAAGEN, 1875c, p. 185, pl. 47, fig. 1a-c; SPATH, 1931a, p. 418, pl. 68, fig. 2, pl. 98, fig. 6, pl. 99, fig. 1). The whorl section and ornamentation are also similar to *Decipia girardoti* ENAY (1966, p. 559, pl. 39, figs. 1a, 3) from the lower Upper Oxfordian, but fasciculate ribbing is not visible in the present specimens.

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite of Keera Dome and Niruna (Jhura Dome).

***Perisphinctes (Arisphinctes) cf. cotovuiiformis*
ENAY, 2009**

Pl. II, fig. 4; Fig. 19; Tab. 10

- cf. 1939. *Perisphinctes (Arisphinctes) cotovui* SIMIONESCU. – ARKELL, p. 126, pl. 24, figs. 1-5, pl. 25, figs. 1-3, pl. A, figs. 1a, b, 4, textfigs. 39-43 (non SIMIONESCU).
cf. 1959b. *Arisphinctes cotovui* SIMIONESCU. – COLLIGNON, pl. 86, fig. 344 (non SIMIONESCU).
cf. 1966. *Perisphinctes (Arisphinctes) gr. cotovui* (SIMIO-

NESCU). – ENAY, p. 410, textfig. 116 (non SIMIONESCU).

cf. 1966. *Perisphinctes* (*Arisphinctes*) cf. *cotovui* (SIMIONESCU). – ENAY, p. 411, textfig. 116 (non SIMIONESCU).

cf. 2009. *Perisphinctes* (*Arisphinctes*) cf. *cotovuiiformis* ENAY, p. 96, pl. 5, fig. 1a, b, Fig. 30.

Material: One specimen from the Kantkote Ammonite Beds in the Tramu River, Wagad Uplift (GZN2010I 257).

Description: Shell large, almost complete, evolute. Whorl section subquadrangular with slightly arched lateral surface. Inner whorls compressed, outer whorls increasingly depressed. Ornamentation consists of gradually variocostate ribs, changing from moderately coarse in inner whorls to broad folds in outermost whorl. Primaries long, slightly concave forward, originating at umbilical suture and branching into three secondaries at the ventrolateral shoulder, which cross the venter with slight forward-directed convexity. Secondaries diminish on body chamber. Umbilical wall steep, slightly arched.

Remarks: The ornamentation, rib curve, and

proportional dimensions compare well with *Perisphinctes* (*Arisphinctes*) *cotovui* SIMIONESCU as described and illustrated by ARKELL (1939). Since the original specimens of SIMIONESCU (1907) have been collected from the Upper Oxfordian (Bimammatum Zone), ENAY (2009) placed them in the genus *Lithacosphinctes* and assigned most of the European forms from the Middle Oxfordian to a new taxon, *Perisphinctes* (*Arisphinctes*) *cotovuiiformis*.

Ornamentation and proportional dimensions, except for whorl thickness, of the present specimen are also very close to *P.* (*Perisphinctes*) *parandieri* DE LORIO (in DE LORIO & GIRARDOT, 1903, p. 90, pl. 7, non pl. 8; BUCKMAN, 1925, p. 63; ARKELL, 1939, p. 105, textfigs. 28-33; ENAY, 1966, p. 357, pl. 5, figs. 1-3, pls. 6, 7, textfigs. 96, 98-100; GYGI, 2001, p. 55, figs. 83, 84), but the change in thickness and spacing of ribs on the outer whorl of the present specimen is gradual. It is important to mention here that of several junior species in the synonymy of *parandieri* (compare ARKELL, 1939; ENAY, 1966) *P. ingens* BUCKMAN and *P. holtonensis* (BUCKMAN) are more compressed, similar to the present

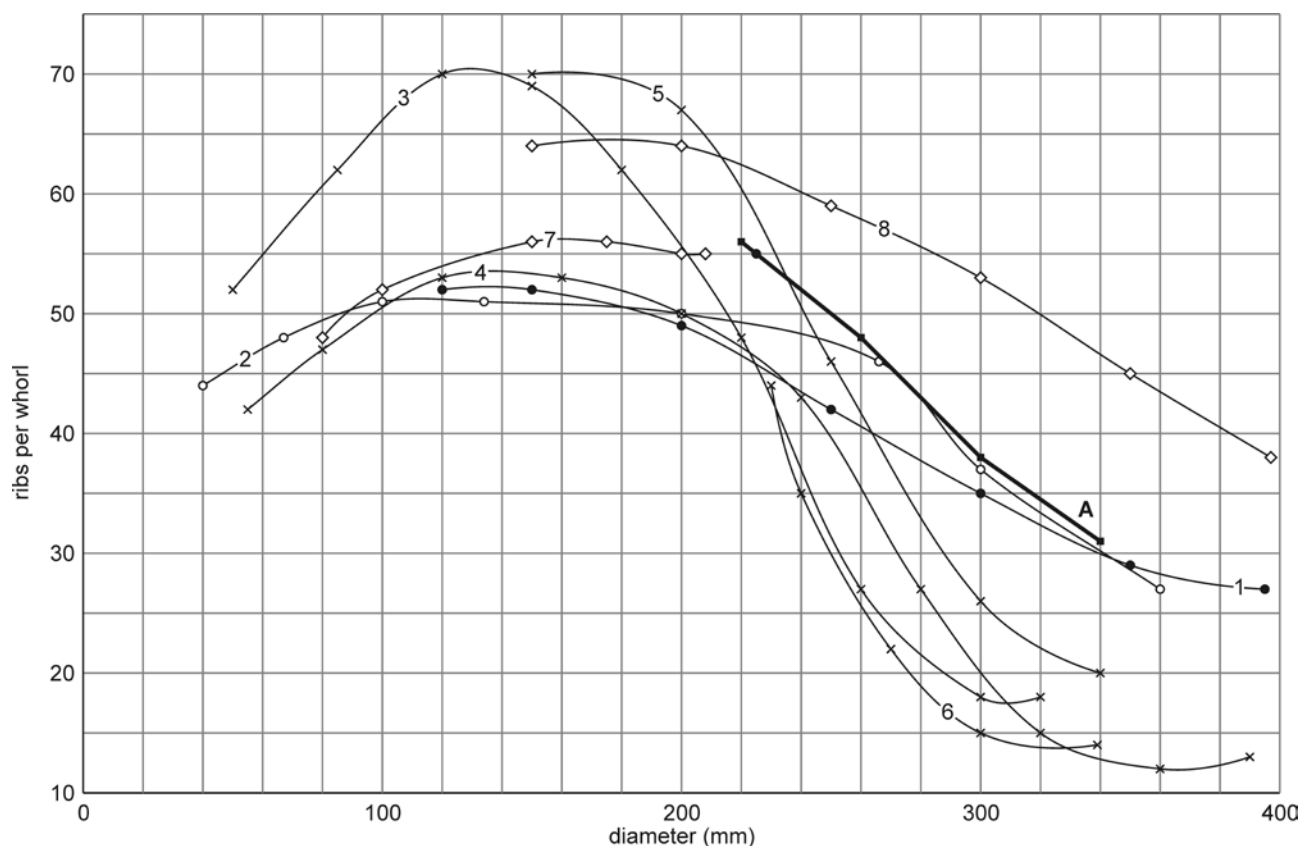


Fig. 19: Rib curve of *Perisphinctes* (*Arisphinctes*) cf. *cotovuiiformis* ENAY, 2009 from the Kachchh Basin (A: GZN2010I 257) compared to previously published curves of this species (1: holotype, ENAY, 2009, fig. 30), of *Lithacosphinctes cotovui* (SIMIONESCU, 1907) (2: lectotype, ENAY, 2009, fig. 30), of *Perisphinctes* (*Perisphinctes*) *parandieri* DE LORIO, 1903 (3: ENAY, 1966, textfig. 99, no. 11; 4: neotype, ENAY, 1966, textfig. 99; 5: ENAY, 1966, textfig. 99, no. 13; 6: lectotype, ENAY, 1966, textfig. 99), and of *Perisphinctes* (*Arisphinctes*) *pickeringius* (YOUNG & BIRD, 1822) (7: holotype, ARKELL, 1939, textfig. 46; 8: ARKELL, 1939, textfig. 46, no. 3).

specimen. *P. ingens* BUCKMAN has been assigned to *Arisphinctes* (ARKELL, 1937, p. xlvii). The spacing of ribs in the present specimen is gradually increasing even up to half of the body chamber in contrast to *parandieri*, where it changes abruptly at the beginning of the body chamber. The ribbing in the middle whorls of specimen GZN2010I 257 compares well with rib curves previously constructed for *parandieri* (56 ribs per whorl at a diameter of 220 mm). Nevertheless, specimen GZN2010I 257 still has 31 ribs in the outermost whorl, while other representatives of *parandieri* only have between 13 to 20 ribs at similar diameters (Fig. 19). *Perisphinctes pickeringius* (YOUNG & BIRD) is similar in overall morphology (ARKELL, 1939, p. 134, pl. 26, figs. 1-4, pl. 27, figs. 1-6, pl. 28, figs. 1, 2, 5, pl. A, fig. 6, textfigs. 43-47; ENAY, 1966, p. 412, fig. 116), but its ribbing density decreases less rapidly in the outer whorls. At a diameter of around 350 mm, this species has still more than 40 ribs per whorl, while the present specimen has only around 30 ribs (Fig. 19).

Perisphinctes (Arisphinctes) aff. cotovuiformis

ENAY, 2009

Pl. VII, figs. 1, 2; Fig. 20; Tab. 11

- aff. 1939. *Perisphinctes (Arisphinctes) cotovui* SIMIONESCU. – ARKELL, p. 126, pl. 24, figs. 1-5, pl. 25, figs. 1-3, pl. A, figs. 1a, b, 4, textfigs. 39-43 (non SIMIONESCU).
 aff. 1959b. *Arisphinctes cotovui* SIMIONESCU. – COLLIGNON, pl. 86, fig. 344 (non SIMIONESCU).
 aff. 2009. *Perisphinctes (Arisphinctes) cf. cotovuiformis* ENAY, p. 96, pl. 5, fig. 1a, b, Fig. 30.

Material: One specimen from the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome (GZN2009II 207).

Description: Shell moderately large, incomplete, evolute, depressed. Whorl section subquadrangular, with broad, rounded venter (Fig. 20A). Ornamentation consists of thick, prorsiradiate ribs, branching into two,

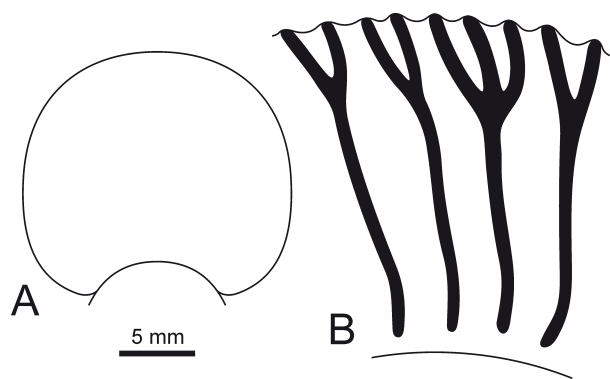


Fig. 20: *Perisphinctes (Arisphinctes) aff. cotovuiformis* ENAY, 2009; Dhosa Conglomerate Bed, Rudra Mata, Habo Dome; GZN2009II 207. A. Whorl section at ca. 62 mm diameter. B. Ribbing pattern on left flank at ca. 76 mm diameter.

rarely three, finer secondaries at ventrolateral shoulder (Fig. 20B). Secondaries cross the venter with a very slight forward-directed convexity. Constrictions distinct.

Remarks: The broad, rounded venter, the style of ornamentation and the number of ribs match *Perisphinctes (Arisphinctes) pickeringius* (YOUNG & BIRD) figured by ARKELL (1939, pl. 26, figs. 1-4, pl. 27, figs. 1-6, pl. 28, figs. 1, 2, 5), but *pickeringius* is slightly compressed. ARKELL (1939, p. 133) mentioned that *P. (Arisphinctes) pickeringius* (YOUNG & BIRD) grades into *Perisphinctes (Arisphinctes) cotovui* [= *P. (A.) cotovuiformis*; following ENAY, 2009]. The whorl section of the latter species described here is depressed at smaller diameter. The specimens from the Lower Oxfordian “Couches à spongiaires” of France (COURVILLE *et al.*, 2000) assigned to *Perisphinctes (Arisphinctes) gr. cotovui* and *Perisphinctes (Arisphinctes) cf. cotovui* by ENAY [1966; = *P. (A.) cotovuiformis*] range in diameter from 120 to 190 mm and all of them have a depressed whorl section even at a large diameter. The ornamentation in the present specimen is quite similar to that of *Perisphinctes (Arisphinctes) cf. subcolubrinus*, described below but in *cotovuiformis* the ribbing is slightly denser.

***Perisphinctes (Arisphinctes) kantkotensis* sp. nov.**

Pl. VIII, figs. 6, 7; Figs. 21, 22; Tab. 12

Derivation of name: After the Kantkote Ammonite Beds southwest of Kantkote Village from where the specimen was collected.

Holotype: Specimen GZN2011I 347.

Material: One specimen from the top of the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2011I 347).

Diagnosis: Shell evolute. Inner whorls depressed, outer whorls compressed. Whorl section subrounded. Umbilical wall short, steeply inclined. Ornamentation consists of gradually variocostate, moderately coarse ribs, running consistently forwardly inclined on the flanks. Primary ribs branch regularly into finer secondaries at the ventrolateral region (three on inner and up to six on outer whorls), which cross the venter with slight forward-directed convexity. Secondaries fade away after around 225 mm diameter. Primary ribs on outer whorls gradually become broad and distant. Constrictions distinct, numbering three per whorl.

Description: Shell large, wholly septate, evolute. Inner whorls slightly depressed, outer whorls compressed. Whorl section subrounded with slightly arched flanks merging smoothly into moderately arched venter (Fig. 21). Umbilical wall short, steeply inclined. Ornamentation consists of gradually variocostate, moderately coarse, sharp primary ribs, which originate near the umbilical suture with rursiradiate orientation then turn prorsiradiate at the umbilical margin, running consistently forward on the flanks. Primary ribs branch regularly into finer secondaries at the ventrolateral region (three on inner

and up to six on outer whorls), which cross the venter with slight forward-directed convexity. Secondaries fade away beyond a whorl diameter of around 225 mm. Ribbing density increases until a diameter of around 120 mm, where the shell shows 49 ribs per whorl. From a diameter of around 150 mm, the ribbing density decreases constantly, the primary ribs become broader until only 28

ribs per whorl are present at a diameter of 295 mm (Fig. 22). Constrictions distinct, numbering three per whorl.

Remarks: The ornamentation and proportional dimensions of the specimen match those of *Perisphinctes* (*Arisphinctes*) *kheraensis* SPATH, 1931, described below. SPATH (1931a, p. 420) recorded only the inner whorls of *kheraensis* from the top bed of the Dhosa Oolite at Keera Dome, and therefore could not provide any information about its ontogeny, but the style of ribbing (compare rib curves in Figs. 22 and 24) and the whorl section suggest that it may be a macroconch. The Dhosa Oolite member consists of two major parts, an oolitic sandstone/limestone succession capped by the prominent Dhosa Conglomerate Bed which contains mainly reworked ammonites (SINGH, 1989; ALBERTI *et al.*, 2011). What SPATH (1931a) called the top bed of the Dhosa Oolite most likely is the Dhosa Conglomerate Bed. In the present publication, *kheraensis* has been recorded occurring autochthonously around 40 cm below the Dhosa Conglomerate Bed (see below) in the Cordatum Zone. Most probably the *kheraensis* recorded by SPATH (1931a) from the Dhosa Conglomerate Bed is reworked. The present specimen is the first record of an almost complete phragmocone, whose inner whorls are similar to this species from Kachchh. However, the specimen GZN2011I 347, which is a macroconch, has been collected from the upper part of the Kantkote Ammonite Beds in the Wagad Uplift. The associated ammonites are *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, *P. (Dichotomosphinctes) elisabethae* DE RIAZ, *P. (Dichotomoceras) stenocycloides* SIEMIRADZKI, and additional perisphinctids representing the early Bifurcatus Zone (see Figs. 65, 66). The present record can be viewed from two angles. Either the present specimen is not *kheraensis* but a new species representing a younger derivative of *kheraensis* from a later time

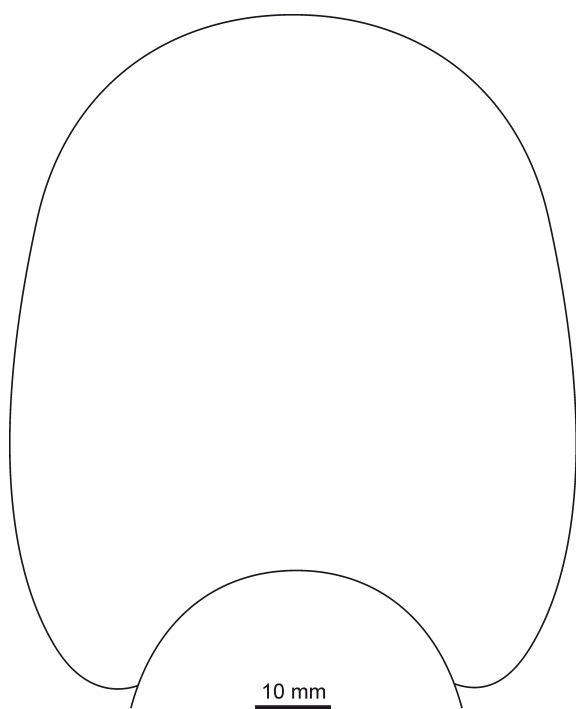


Fig. 21: *Perisphinctes* (*Arisphinctes*) *kantkotensis* sp. nov.; Kantkote Ammonite Beds, Kantkote Village; GZN2011I 347. Whorl section at ca. 290 mm diameter.

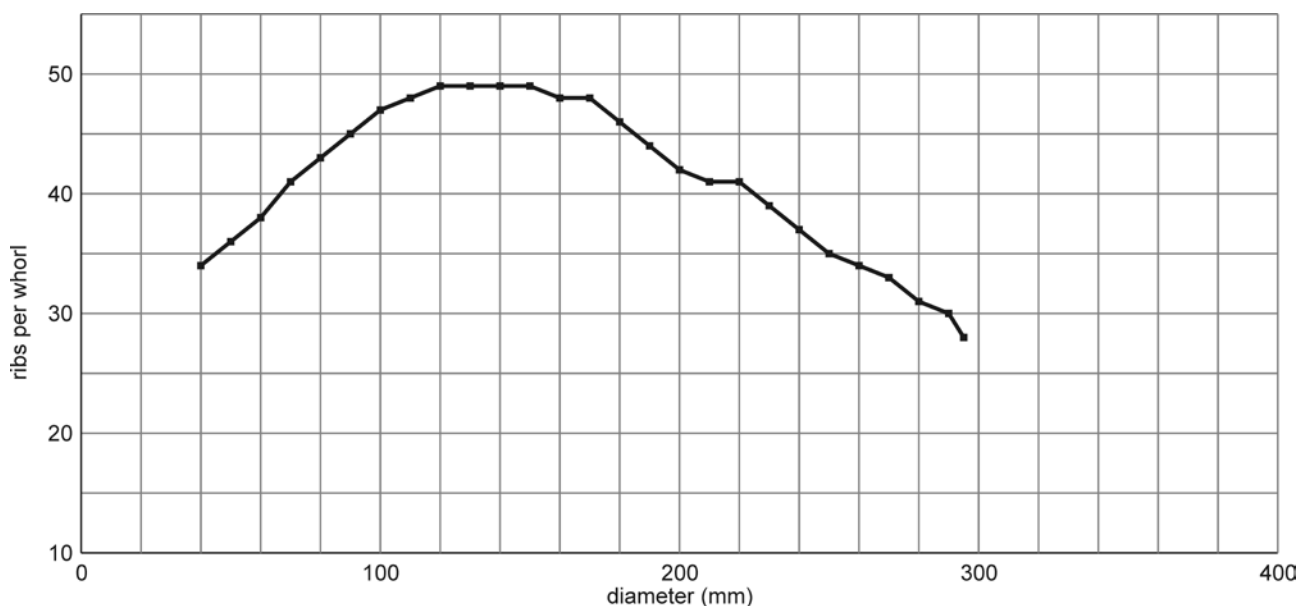


Fig. 22: Rib curve of *Perisphinctes* (*Arisphinctes*) *kantkotensis* sp. nov. from the Kachchh Basin (GZN2011I 347).

interval than that represented by the Dhosa Conglomerate Bed, or *kheraensis* has a very long temporal range. The second point is less likely as rapid temporal changes in *Perisphinctes* are the rule during the Oxfordian and no specimens of *P. (Arisphinctes) kheraensis* have been found in the Middle Oxfordian part of the Kantkote Ammonite Beds.

The ornamentation, particularly the primary ribs, of the present specimen is similar to *Kranaosphinctes* described from the Lower to Middle Oxfordian Plicatilis Zone (see ARKELL, 1939), but dimensional proportions, particularly whorl height and the finer secondaries on the venter easily differentiate it from all species described from the Corallian of England. *Kranaosphinctes (Pachyplanulites) randrianarivonyi* COLLIGNON (1959b, pl. 74, fig. 309) shows a similar ornamentation and a comparable umbilical ratio (Tab. 13), but the Madagascan species is thicker. *Perisphinctes (Arisphinctes) cf. cotovuiformis* ENAY, 2009, as described above, differs by having more evolute and compressed inner whorls.

***Perisphinctes (Arisphinctes) kheraensis* SPATH, 1931
Pl. IX, figs. 1-7; Figs. 23, 24; Tab. 13**

1931a. *Perisphinctes kheraensis* SPATH, p. 420, pl. 74, fig. 5a, b (non pl. 95, fig. 3).

Material: Eleven specimens. Two specimens from the Dhosa Oolite (GZN2009II 060, 195), one specimen from a reworked, concretionary slab floating in the Dhosa Conglomerate Bed (GZN2009II 163), and three specimens from the Dhosa Conglomerate Bed (GZN2009II 010, 011, OUMNH JY.533) of the Jara Dome. One specimen from the Dhosa Conglomerate Bed of the Jumara Dome (GZN2010I 1049). Two specimens from the Dhosa Oolite close to Jhura Camp, Jhura Dome (GZN2009II 076, OUMNH JY.831). One specimen from the Dhosa Conglomerate Bed south of Lodai, Habo Dome (GZN2010I 1014). One specimen from the Dhosa Conglomerate Bed at Ler, southeast of Bhuj (GZN2010I 272).

Description: Shells small to large, incomplete, septate till end, and evolute. Inner whorls slightly depressed, outer whorls compressed. Whorl section subrounded, the slightly convex flanks merge smoothly into the moderately arched venter (Fig. 23A-F). Umbilical wall short, steeply inclined. Ornamentation consists of gradually variocostate, moderately coarse, sharp primary ribs originating near the umbilical suture with rursiradial orientation then turning prorsiradial near the umbilical margin, from where they run consistently forward-inclined on the flanks. Primaries branch regularly into two (rarely three on the outer whorl) finer secondaries at the ventrolateral region (Fig. 23G) and cross the venter with slight forward-directed convexity. Primaries on outer whorls become rectiradial. Ribbing density is moderate, increases during growth until a diameter

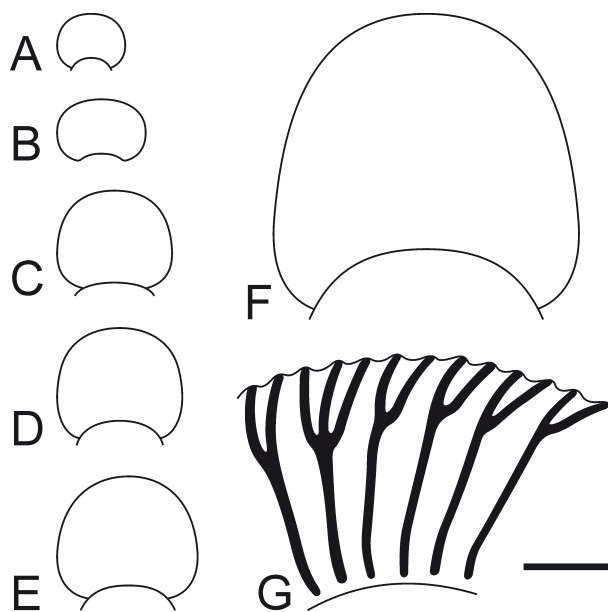


Fig. 23: *Perisphinctes (Arisphinctes) kheraensis* SPATH, 1931. A. Whorl section at ca. 17 mm diameter (scale bar = 10 mm); Dhosa Oolite, Jhura Camp, Jhura Dome; GZN2009II 076. B. Whorl section at unknown diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jumara Dome; GZN2010I 1049. C. Whorl section at ca. 38 mm diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 010. D. Whorl section at unknown diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jumara Dome; GZN2010I 1049. E. Whorl section at ca. 49 mm diameter (scale bar = 10 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 011. F. Whorl section at ca. 125 mm diameter (scale bar = 10 mm); Dhosa Oolite, Jara Dome; GZN2009II 060. G. Ribbing pattern on right flank at ca. 45 mm diameter (scale bar = 5 mm); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 011.

of around 100 mm (Fig. 24). Constrictions distinct, numbering three per whorl.

Remarks: The exact number of constrictions in each whorl of the largest specimen (GZN2009II 060) could not be counted but it is certainly larger than two. The ornamentation and proportional dimensions of the specimens match those of *Perisphinctes kheraensis* SPATH. Unfortunately, SPATH (1931a) did not provide any information about the ontogeny of the species. Nevertheless, the style of ribbing and whorl section suggest that *kheraensis* is a macroconch (Pl. IX, fig. 5). The smaller specimens are inner whorls of this macroconch. At the given diameter *Subgrossouvria blakei* SPATH (1931a, p. 374, pl. 65, fig. 5a, b) from the Callovian of Kachchh shows ornamentation and dimensional proportions similar to these smaller specimens.

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite of Keera Dome and Niruna (Jhura Dome).

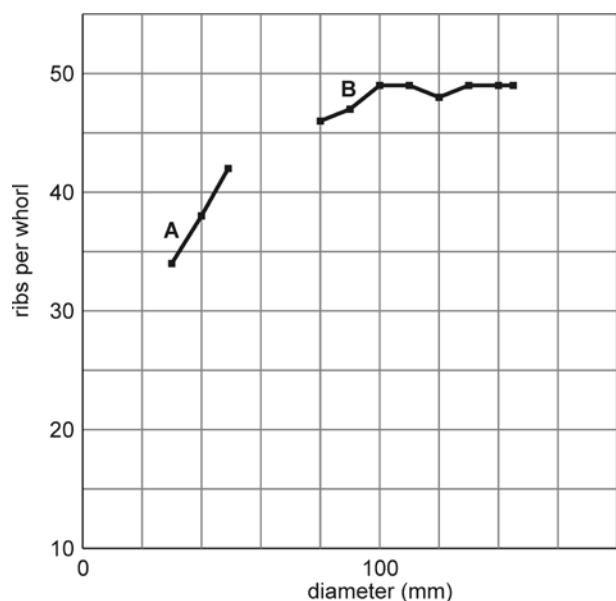


Fig. 24: Rib curves of specimens of *Perisphinctes* (*Arisphinctes*) *kheraensis* SPATH, 1931 from the Kachchh Basin (A: GZN2009II 011; B: GZN2009II 060).

***Perisphinctes* (*Arisphinctes*) *kachchhensis* sp. nov.**
Pl. XI, figs. 5, 6; Figs. 25, 26; Tab. 14

- 1875c. *Perisphinctes plicatilis* (J. SOWERBY). – WAAGEN, p. 189, pl. 51, figs. 2a, b, 3, pl. 52, fig. 3 (non J. SOWERBY).
1931a. *Perisphinctes orientalis* SIEMIRADZKI. – SPATH, p. 416, pl. 69, fig. 1, pl. 72, fig. 2, pl. 74, fig. 3a, b (non SIEMIRADZKI).
1934. *Perisphinctes orientalis* SIEMIRADZKI. – SPATH, p. 4, pl. 4, figs. 1a, b (non SIEMIRADZKI).
1959b. *Perisphinctes orientalis* SIEMIRADZKI. – COLLIGNON, pl. 71, fig. 306 (non SIEMIRADZKI).

Derivation of name: After the Kachchh Basin from where specimens of this species are known since WAAGEN (1875c).

Holotype: The specimen figured by SPATH (1931a, pl. 69, fig. 1, pl. 72, fig. 2; J.F. Blake Colln., No. 532) is assigned as the holotype of the species. The specimen GZN2010I 091 from the same stratigraphic unit and locality, the Kantkote Ammonite Beds near Kantkote Village, is assigned as a syntype.

Material: Six specimens. Five specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 085, 091, 128, GZN2011I 338, 342). One specimen from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 148).

Diagnosis: Shell large, evolute. Inner whorls compressed, but becoming depressed at a diameter of around 150 to 190 mm. Whorl section subquadrangular. Umbilical wall short, steeply inclined. Ornamentation consists of very gradually varicostate, slightly prorsiradiate, thick primary ribs, originating at the umbilical margin. At the ventrolateral shoulder the primaries regularly branch into two thinner secondaries, which cross the venter with slight forward-directed convexity. Secondaries disappear on outer whorl. From a diameter of 140 mm, the ribbing density decreases. Constrictions faintly developed, on inner whorls only.

Description: Shell large, incomplete, wholly septate, and evolute. Inner whorls compressed, but becoming depressed at a diameter of around 150 to 190 mm (Fig. 25A). Ornamentation consists of very gradually varicostate, slightly prorsiradiate, thick primary ribs, originating at the umbilical margin. At the ventrolateral shoulder the primaries regularly branch into two thinner secondaries (Fig. 25B,C), which cross the venter with slight forward-directed convexity. Secondaries disappear on outer whorl (Fig. 25D). Ribbing density is moderate to dense, increases until a diameter of around 100 mm where the whorl has 60 ribs (Fig. 26). From a diameter of 140 mm, the ribbing density decreases. Umbilical wall low, steep, and slightly arched. Constrictions faintly developed, on inner whorls only.

Remarks: Following SPATH (1931a), a series of authors have identified ammonites from the Kachchh Basin as

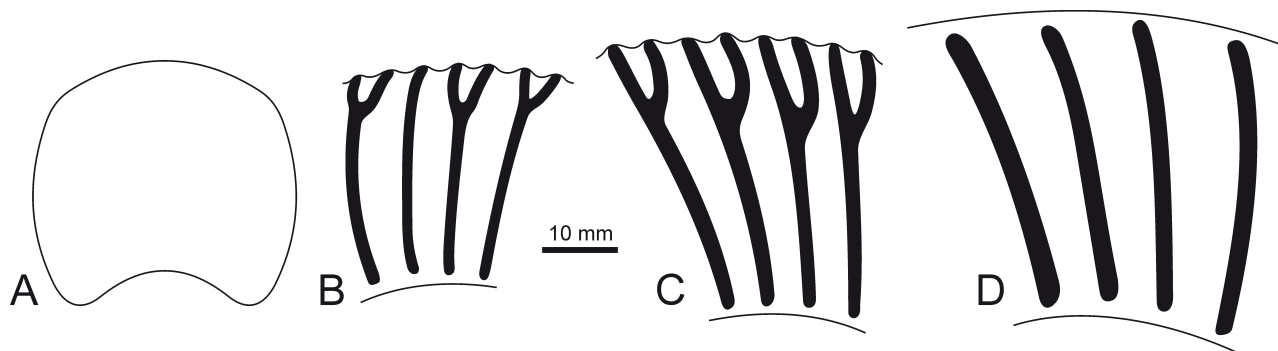


Fig. 25: *Perisphinctes* (*Arisphinctes*) *kachchhensis* sp. nov.; Kantkote Ammonite Beds, Kantkote Village. A. Whorl section at unknown diameter; GZN2010I 085. B. Ribbing pattern on right flank at unknown diameter; GZN2010I 085. C. Ribbing pattern on left flank at ca. 130 mm diameter; GZN2010I 091. D. Ribbing pattern on left flank at ca. 160 mm diameter; GZN2010I 091.

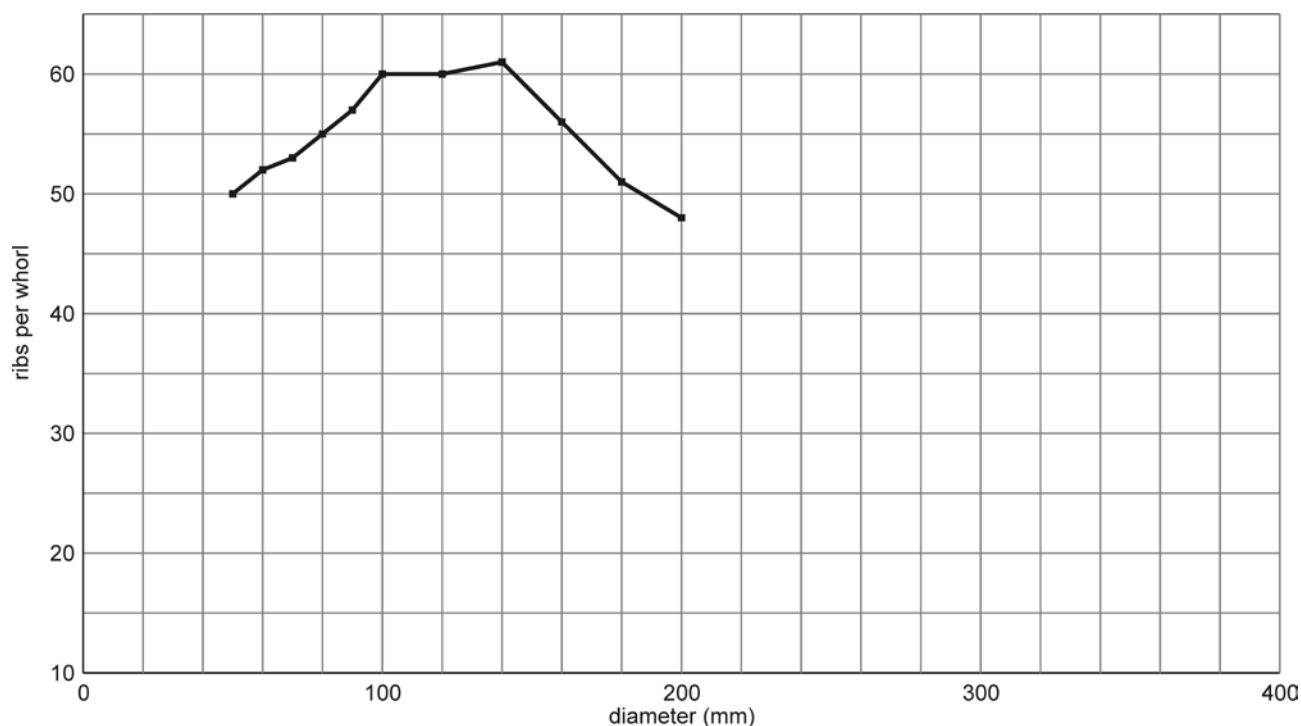


Fig. 26: Rib curve of *Perisphinctes (Arisphinctes) kachchensis* sp. nov. from the Kachchh Basin (GZN2010I 091).

Perisphinctes orientalis SIEMIRADZKI. However, a series of taxonomic misunderstandings surround this taxon which are briefly discussed in the following.

WAAGEN (1875c) described several ammonites from the Kachchh Basin as *Perisphinctes plicatilis* (J. SOWERBY), which were subsequently included by SIEMIRADZKI (1891) into the synonymy of his new species, *Perisphinctes orientalis* from Poland. Nevertheless, SIEMIRADZKI (1891) figured only one incomplete specimen for this new taxon. In his prominent monograph on the Indian ammonite fauna, SPATH (1931a) followed the opinion of SIEMIRADZKI (1891) and described further specimens as *Perisphinctes orientalis*. Following on this, ARKELL (1939, p. 157) considered *Perisphinctes orientalis* to be an Indian species based mainly on the material of WAAGEN (1875c). However, ENAY (1966) showed that the specimens described by SIEMIRADZKI (1891) from Poland and those from Kachchh do not belong to the same species. This can also be well seen in the present material: while the specimens match the descriptions and illustrations of SPATH (1931a) and WAAGEN (1875c), a comparison with the Polish material of SIEMIRADZKI (1891, pl. 2, fig. 2) does reveal that the Kachchh specimens have thinner, denser, more uniformly prorsiradiate ribs, which bifurcate more regularly on the internal whorls. This raises the question, whether the name *Perisphinctes orientalis* should be retained for the Polish or the Kachchh specimens. ENAY (1966) discussed these taxonomic problems and introduced a new name, *Perisphinctes siemiradzki*, for the Polish material, seemingly retaining

Perisphinctes orientalis for the Kachchh specimens. Nevertheless, although not clearly stated by SIEMIRADZKI (1891), it would be expected to consider the only figured specimen in the original description as the holotype. Here we follow this view, which necessitates a new species for the Kachchh specimens i.e., *Perisphinctes (Arisphinctes) kachchensis*. Furthermore, the European specimens included by ENAY (1966) in *Perisphinctes siemiradzki* are microconchs, whereas the Kachchh specimens are macroconchs, still septate at large diameters.

Earlier records from the Kachchh Basin: The specimens figured by WAAGEN (1875c) as *Perisphinctes plicatilis* and later on identified as *Perisphinctes orientalis* by SPATH (1931a) are from the Kantkote Sandstone (Wagad Uplift). WAAGEN (1875c) described additional, similar specimens from other localities of Kachchh Mainland, Wagad Uplift, and Gangta Bet (compare SPATH, 1931a).

***Perisphinctes (Arisphinctes) polymorphus*
(SPATH, 1931)**

Pl. VIII, figs. 2-5; Figs. 27, 28; Tab. 15

- 1931a. *Alligaticeras polymorphum* SPATH, p. 409, pl. 73, figs. 3a, b (holotype), pl. 99, fig. 2.
non 1959a. *Alligaticeras polymorphum* SPATH. – COLLIGNON, pl. 43, fig. 220.

Material: Seventeen specimens. One specimen from the Dhosa Oolite (GZN2009II 018) and fifteen specimens from the Dhosa Conglomerate Bed (GZN2009II 017, 019-021, GZN2010I 1074, 1079, 1081, OUMNH

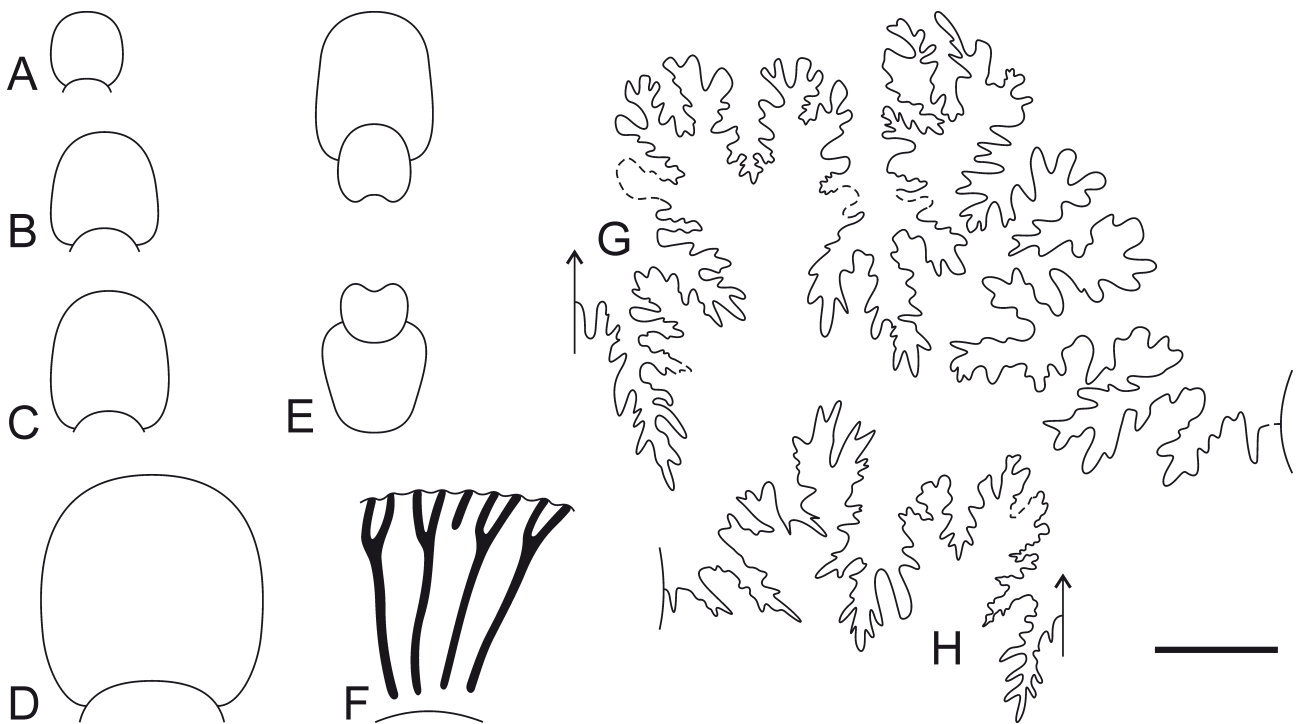


Fig. 27: *Perisphinctes* (*Arisphinctes*) *polymorphus* (SPATH, 1931); Dhosa Conglomerate Bed, Jara Dome (A-C, E, F, H) and Jumara Dome (D, G). A. Whorl section at ca. 27 mm diameter (scale bar = 15 mm); GZN2009II 021. B. Whorl section at ca. 40 mm diameter (scale bar = 15 mm); GZN2009II 017. C. Whorl section at unknown diameter (scale bar = 15 mm); GZN2010I 1081. D. Whorl section at ca. 87 mm diameter (scale bar = 15 mm); GZN2009II 016. E. Cross section (scale bar = 15 mm); GZN2010I 1074. F. Ribbing pattern on right flank at ca. 40 mm diameter (scale bar = 7.5 mm); GZN2009II 017. G. Suture line at ca. 55 mm diameter (scale bar = 5 mm); GZN2009II 016. H. Suture line at ca. 35 mm diameter (scale bar = 5 mm); GZN2009II 017.

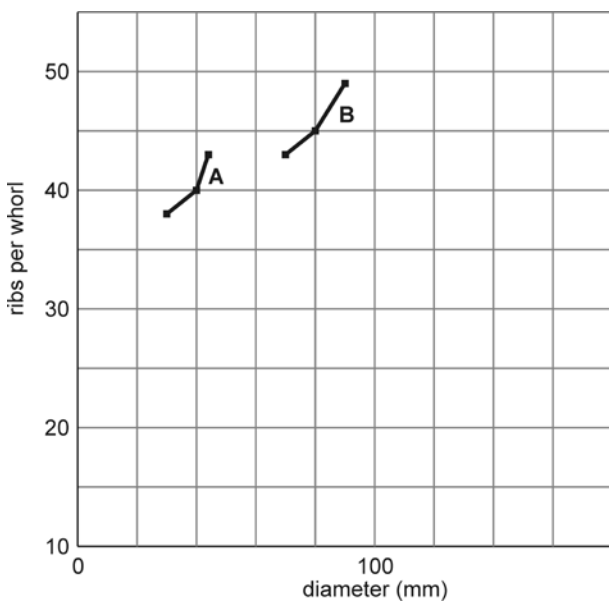


Fig. 28: Rib curves of specimens of *Perisphinctes* (*Arisphinctes*) *polymorphus* (SPATH, 1931) from the Kachchh Basin (A: GZN2009II 018; B: GZN2009II 016).

JY.474, JY.476, JY.477, JY.478, JY.480, JY.535, JY.538, JY.881) of the Jara Dome. One specimen from the Dhosa Conglomerate Bed of the Jumara Dome (GZN2009II 016).

Description: Shells small, septate till end, evolute, compressed. Whorl section subquadrangular with flat sides and narrowly rounded venter (Fig. 27A-E), umbilical wall distinct but short and vertical. Ornamentation consists of gradually varicostate (fine in the inner whorls and moderately thick in the middle whorls) and sharp primary ribs beginning in a slightly rursiradiate fashion near the umbilical margin to turn prorsiradiately on the flanks. They branch regularly into two finer secondaries just short of the ventrolateral shoulder. The secondaries diminish towards the mid venter and exhibit a slight forward-directed convexity. Ribbing density is moderate, gradually increasing during growth (Fig. 28). Constrictions are shallow, numbering at least two per whorls.

Remarks: The specimens match *Perisphinctes* (*Arisphinctes*) *polymorphus* as described and illustrated by SPATH (1931a). In addition, their ornamentation, general shape of the whorl section, and proportional

dimensions are also similar to *Alligaticeras* aff. *polymorphum* as described by SPATH (1931a, p. 409, pl. 73, fig. 4) and COLLIGNON (1959b, pl. 69, figs. 301, 302). Nevertheless, the specimens of COLLIGNON (1959a, b) from Madagascar are slightly more evolute than the present specimens and also *A. polymorphum* as described by SPATH (1931a). In addition, COLLIGNON (1959a, b) recorded the species from the Upper Oxfordian, a higher level than in the Kachchh Basin, which supports their exclusion from the synonymy list.

Most of the specimens are wholly septate, only specimen GZN2009II 018 has parts of the body chamber preserved. Since the suture lines are still placed regularly and the morphological characters of this specimen match the inner whorls of other specimens well, it is considered a juvenile.

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite of Keera Dome, Niruna (Jhura Dome), Fakirwari, Samatra, and from the Charwar Hills (i.e. outcrops along the Katrol Hill Fault, south of Bhuj).

***Perisphinctes (Arisphinctes) cf. subcolubrinus*
WAAGEN, 1875**

Pl. XI, figs. 3, 4; Fig. 29; Tab. 16

- cf. 1875c. *Perisphinctes subcolubrinus* WAAGEN, p. 180, pl. 49, fig. 3a, b.
cf. 1931a. *Pachyplanulites subcolubrinus* (WAAGEN). – SPATH, p. 432, pl. 70, fig. 1a, b, pl. 73, fig. 7a, b.

Material: Four specimens. Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 064, 065). One stray specimen from the Tramau River, Wagad Uplift (GZN2010I 234). One stray specimen with unknown locality (GZN2010I 264).

Description: Shells large, incomplete, evolute, compressed. Whorl section subquadrate with flat flanks (Fig. 29A-C). Ornamentation consists of thick, distant, prorsiradiate, forwardly concave primary ribs, which branch into two or three finer secondaries at the umbilical suture with the following whorl (Fig. 29D), and cross the venter with broad forward-directed convexity.

Remarks: These are fragmentary specimens. The ornamentation and whorl section match those of *P. (Arisphinctes) subcolubrinus*. The ornamentation of specimen GZN2010I 064 also resembles *Perisphinctes (Arisphinctes) cotovuiiformis* ENAY. The ornamentation of specimen GZN2010I 234 differs from *Perisphinctes (Dichotomosphinctes) tizianiformis* CHOFFAT described below by its lower point of branching and more distant ribs. The specimen is also larger in diameter than the adult (microconch) of *tizianiformis* in the present collection. Owing to the fragmentary nature of the specimens they have been assigned to this species only tentatively.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described the species from the Kantkote Sandstone (Wagad Uplift). SPATH (1931a) mentions the species from the same locality.

***Perisphinctes (Arisphinctes) cf. trifidus*
(J. SOWERBY, 1821)**

Pl. XII, figs. 6, 7; Fig. 30; Tab. 17

- cf. 1821. *Ammonites trifidus* J. SOWERBY, p. 194.
cf. 1898. *Perisphinctes helenae* DE RIAZ, p. 15, pl. 8, fig. 1.
cf. 1931a. *Dichotomosphinctes helenae* (DE RIAZ). – SPATH, p. 436, pl. 68, fig. 9, pl. 70, fig. 5.
cf. 1939. *Perisphinctes (Arisphinctes) helenae* DE RIAZ. – ARKELL, p. 149, pl. 30, figs. 7, 8, pl. 31, figs. 1-3, textfigs. 48, 49.
cf. 1959b. *Arisphinctes helenae* DE RIAZ. – COLLIGNON, pl. 67, fig. 295.

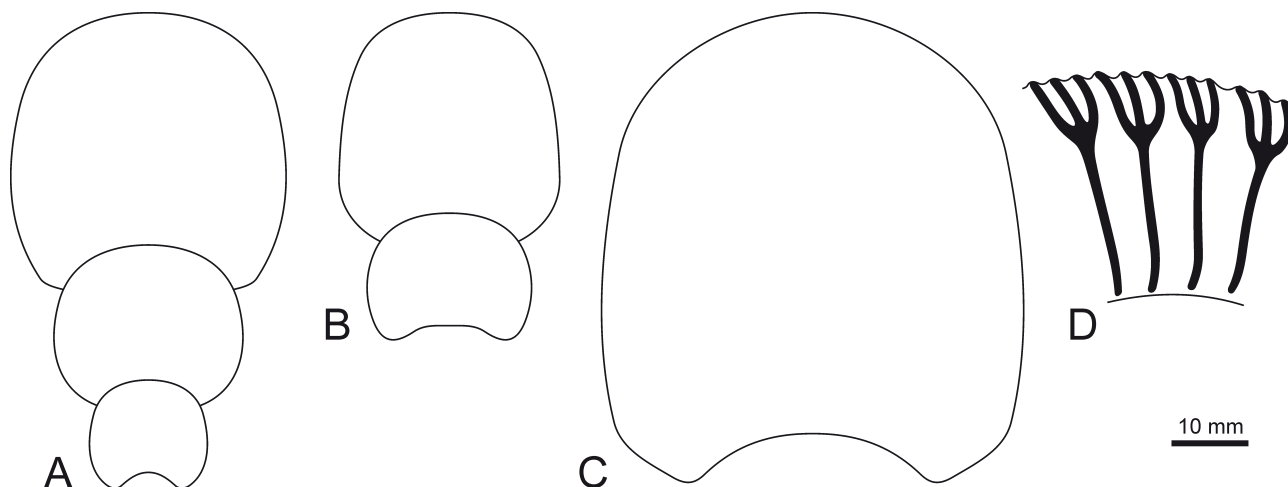


Fig. 29: *Perisphinctes (Arisphinctes) cf. subcolubrinus* WAAGEN, 1875; Kantkote Ammonite Beds, Kantkote Village (A, C) and unknown locality (B, D). A. Whorl sections at unknown diameter; GZN2010I 064. B. Whorl sections at unknown diameter; GZN2010I 264. C. Whorl section at unknown diameter; GZN2010I 065. D. Ribbing pattern on left flank at unknown diameter; GZN2010I 264.

- cf. 1966. *Perisphinctes* (*Arisphinctes*) *helenae* (DE RIAZ). – ENAY, p. 413, pl. 20, figs. 1-4, textfigs. 118, 119.
 cf. 2000. *Perisphinctes* (*Arisphinctes*) *helenae* DE RIAZ. – GYGI, p. 82, pl. 3, fig. 2, textfig. 43.
 cf. 2001. *Perisphinctes* (*Arisphinctes*) *helenae* DE RIAZ. – GYGI, p. 29, figs. 36, 37.
 cf. 2002. *Perisphinctes trifidus* (J. SOWERBY). – GLOWNIAK, p. 321, pl. 10, figs. 2-3, pl. 11, figs. 1-3, pl. 12, figs. 1-2, textfigs. 8, 10, 11 (see for extensive synonymy).

Material: Seven specimens. One specimen from the Dhosa Oolite (OUMNH JY.269) and five specimens from the Dhosa Conglomerate Bed (GZN2009II 149, 204, 228, GZN2010I 1075, 1082) of the Jara Dome. One specimen from a thin layer of Dhosa Oolite on top of the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome (GZN2009II 114).

Description: Shells small, evolute, incomplete. Whorl section compressed and rounded to subrectangular (Fig. 30A, B). Feebly arched flanks merge into venter at obtusely rounded ventrolateral shoulder. Maximum thickness of whorl at one-third of flank height. Ornamentation consists of fine, isocostate, prorsiradiate primary ribs, bifurcating regularly at the ventrolateral shoulder (Fig. 30C). Secondaries cross the venter with slight forward-directed convexity. Four constrictions per whorl.

Remarks: The specimens match illustrations and descriptions of *Perisphinctes helenae*. The fine, isocostate, regularly bifurcating primary ribs of the present specimens representing internal whorls suggest an assignment to the subgenus *Dichtomosphinctes* (compare SPATH, 1931a). Nevertheless, previous authors who could examine the ornamentation on the body whorl assigned the species as a macroconch to *Arisphinctes* (e.g., ARKELL, 1939; ENAY, 1966; GYGI, 2000, 2001). In a more recent study, GLOWNIAK (2002) put *P. helenae* in synonymy of *Perisphinctes trifidus*, a view which is followed here.

The shell of specimen GZN2009II 114 (Pl. XII, fig. 7) is preserved with three quarters of the last whorl

representing the body chamber. Due to its small size and the regularly placed suture lines, it should be considered as a juvenile. *Perisphinctes rota* WAAGEN (1875c, p. 186, pl. 48, fig. 1a, b) has similar dimensional proportions, although the present specimens are smaller in diameter. The rounded whorl section differentiates the specimens from *Perisphinctes* (*Dichtomosphinctes*) *subhelenae* SPATH, described below.

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite of the Jumara Dome as well as from the Kantkote Sandstone (Wagad Uplift).

***Perisphinctes* (*Arisphinctes*) *rota* WAAGEN, 1875
 Pl. XIII, figs. 5, 7-9; Figs. 31, 32; Tab. 18**

- 1875c. *Perisphinctes rota* WAAGEN, p. 186, pl. 48, fig. 1a, b (holotype).
 1931a. *Otosphinctes rota* (WAAGEN). – SPATH, p. 410, pl. 72, fig. 8a, b.
 1959b. *Perisphinctes* (*Otosphinctes*) *rota* WAAGEN. – var. *fasciculata* COLLIGNON, pl. 62, fig. 282.
 1959b. *Perisphinctes* (*Otosphinctes*) *rota* WAAGEN. – var. *constricta* COLLIGNON, pl. 68, fig. 298.

Material: Four specimens. One specimen from the Dhosa Conglomerate Bed of the Jumara Dome (GZN2010I 1059). One specimen from the Dhosa Oolite (OUMNH JY.925) and one specimen from the Dhosa Conglomerate Bed (GZN2009II 227) close to Kamaguna, Jhura Dome. One specimen from the Dhosa Conglomerate Bed close to Kotai, Habo Dome (OUMNH JY.1259).

Description: Shells moderately large, evolute, incomplete. Whorl section slightly compressed, suboval to subquadrate with maximum thickness at one-fourth of whorl height, and rounded venter (Fig. 31A). Umbilical wall indistinct, umbilical margin obtusely rounded. Ornamentation consists of gradually varicostate, moderately sharp, dense (inner whorls) to more distant (outer whorls; Fig. 31B) primary ribs originating at umbilical wall near the umbilical margin with rursiradiate orientation then becoming prorsiradiate near the

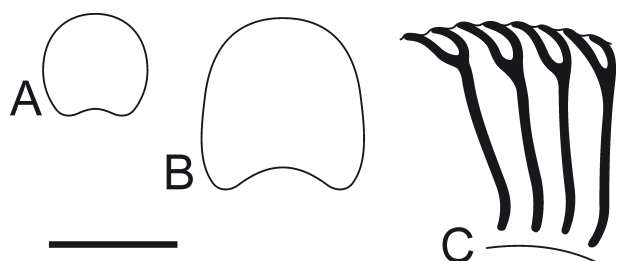


Fig. 30: *Perisphinctes* (*Arisphinctes*) cf. *trifidus* (J. SOWERBY, 1821); Dhosa Conglomerate Bed, Jara Dome; GZN2009II 204. A. Whorl section at unknown diameter (scale bar = 15 mm). B. Whorl section at unknown diameter (scale bar = 15 mm). C. Ribbing pattern on left flank at unknown diameter (scale bar = 10 mm).



Fig. 31: *Perisphinctes* (*Arisphinctes*) *rota* WAAGEN, 1875; Dhosa Conglomerate Bed, Jumara Dome (A) and Kamaguna, Jhura Dome (B). A. Whorl section at unknown diameter; GZN2010I 1059. B. Ribbing pattern on right flank at unknown diameter; GZN2009II 227.

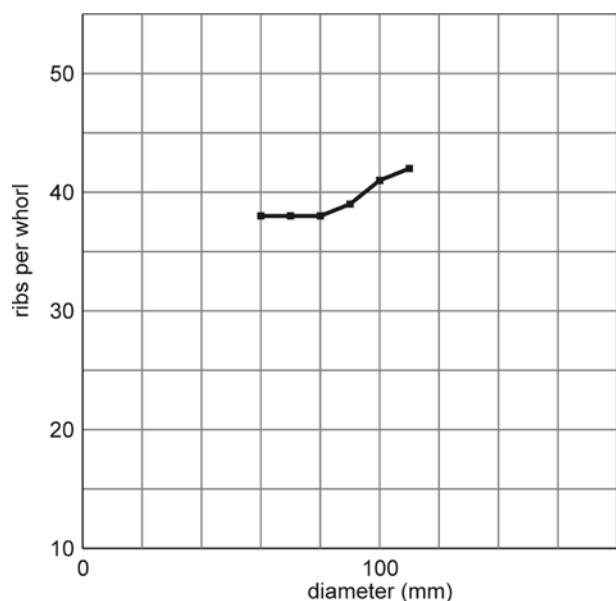


Fig. 32: Rib curve of *Perisphinctes* (*Arisphinctes*) *rota* WAAGEN, 1875 from the Kachchh Basin (OUMNH JY.925).

umbilical margin. Primary ribs branch regularly into two secondaries just below the ventrolateral shoulder, which cross the venter with slight forward-directed convexity. Ventral region of outer whorls almost smooth. Ribbing density low to moderate, increasing slightly from diameters of 60 mm to 110 mm (Fig. 32). Constrictions distinct, numbering at least three per whorl.

Remarks: The ornamentation and whorl section match *P.* (*Arisphinctes*) *rota*. The figure given by WAAGEN (1875c, pl. 48, fig. 1) referred to by SPATH (1931a) as the holotype, is merely the best of thirteen syntypes. This species differs from the nearest ally, *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* SPATH (1931a, p. 430, pl. 96, fig. 5), described above, by its slightly more evolute shell, the compressed whorl section and a slightly lower point of bifurcation. One of the specimens (OUMNH JY.348), which has been assigned to *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* SPATH, possesses an intermediate character as far as the evolution of the shell is concerned. Since the whorls in this specimen are depressed and the point of bifurcation is at the ventrolateral shoulder it has been identified as *nerunaensis*. The maximum thickness of the whorls is attained more towards the central region of the flanks as in the early whorls of *rota* and *nerunaensis*.

Both varieties of *rota* described by COLLIGNON (1959b; i.e. var. *fasciculata*, pl. 62, fig. 282, and var. *constricta*, pl. 68, fig. 298) from Madagascar are slightly thicker, but still have been retained in synonymy.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described the species from the Dhosa Oolite of the Jara (northwest of Soorka) and Keera domes, as well as from Wanda. SPATH (1931a) mentioned the species

from the Dhosa Oolite of Jara and Jumara domes, South Manjal, Gajansar, Niruna and Kamaguna (both Jhura Dome), Ler, Samatra, and Fakirwari.

Subgenus *Liosphinctes* BUCKMAN, 1925

Type species: *Liosphinctes apolipon* BUCKMAN, 1925.

Remarks: Shells intermediate between *Arisphinctes* and *Dichotomosphinctes*, with constrictions. Ribs are fine and dense, but fade on the outer whorl. Peristome simple (ARKELL *et al.*, 1957; GLOWNIAK, 2002). GLOWNIAK (2002; see also GLOWNIAK & WIERZBOWSKI, 2007) proposed *Liosphinctes* to be a separate genus, but due to its close affinities to other members of *Perisphinctes* (such as *Arisphinctes* and *Kranaosphinctes*; compare ARKELL, 1939; GEYER, 1961), the present study treats it only as a subgenus (compare CALLOMON, 1960; MALINOWSKA, 1972a).

Perisphinctes (*Liosphinctes*) *plicatilis* (J. SOWERBY, 1817)

Pl. X, figs. 1-8; Figs. 33, 34; Tab. 19

- 1817. *Ammonites plicatilis* J. SOWERBY, p. 149, pl. 166.
- non 1875c. *Perisphinctes plicatilis* J. SOWERBY. – WAAGEN, p. 189, pl. 51, figs. 2a, b, 3 (= *Perisphinctes* (*Arisphinctes*) *kachchhensis* sp. nov.).
- 1939. *Perisphinctes* (*Arisphinctes*) *plicatilis* (J. SOWERBY). – ARKELL, p. 145, pl. 29, figs. 1-8, textfig. 41.
- 1966. *Perisphinctes* (*Arisphinctes*) *plicatilis* (J. SOWERBY). – ENAY, p. 416, pl. 19, fig. 2, textfig. 117.
- 2000. *Perisphinctes* (*Arisphinctes*) *plicatilis* (J. SOWERBY). – GYGI, p. 81, pl. 3, fig. 1, textfig. 42.
- 2001. *Perisphinctes* (*Arisphinctes*) *plicatilis* (J. SOWERBY). – GYGI, p. 22, figs. 25, 26.
- 2002. *Liosphinctes plicatilis* (J. SOWERBY). – GLOWNIAK, p. 347, pl. 16, figs. 1-2, pl. 17, figs. 1-2, textfigs. 23, 24.

Material: Twenty-eight specimens. One specimen from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 066). Twenty-four specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 165, 167, 168, 173, 174, 176, 178, 188, 191, 193, 195, 198, 211, 212, 216-218, 220, 245, 251, 253-256). Two stray specimens from the Trama River, Wagad Uplift (GZN2010I 239, 242). One stray specimen with unknown locality (GZN2010I 261).

Description: Shells small to large, incomplete, septate till end, evolute. Inner whorls depressed, but becoming compressed around 40 mm of shell diameter. Whorl section quadrate in inner whorls, oval in outer whorls with convex to flat flanks merging smoothly into the obtusely rounded venter (Fig. 33A-G). Maximum inflation near umbilical margin. Ornamentation consists

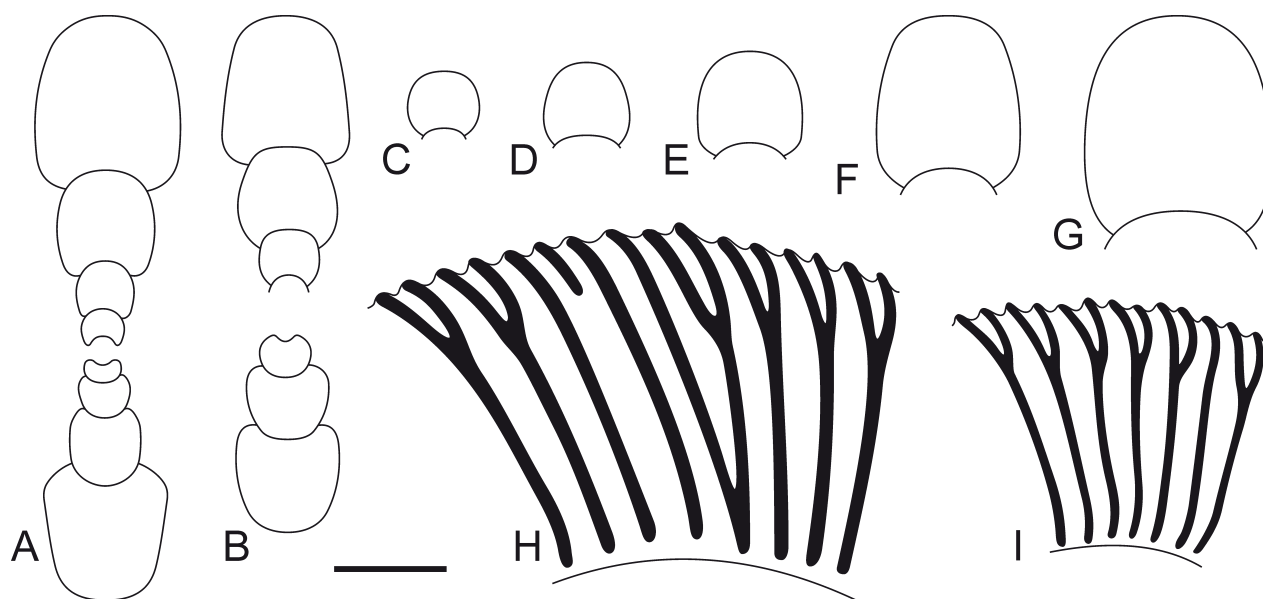


Fig. 33: *Perisphinctes* (*Liosphinctes*) *plicatilis* (J. SOWERBY, 1817); Kantkote Ammonite Beds, Trama River (A-E, G, H) and unknown locality (F, I). A. Cross section (scale bar = 15 mm); GZN2010I 256. B. Cross section (scale bar = 15 mm); GZN2010I 174. C. Whorl section at ca. 22 mm diameter (scale bar = 15 mm); GZN2010I 174. D. Whorl section at ca. 35 mm diameter (scale bar = 15 mm); GZN2010I 211. E. Whorl section at unknown diameter (scale bar = 15 mm); GZN2010I 176. F. Whorl section at ca. 72 mm diameter (scale bar = 15 mm); GZN2010I 261. G. Whorl section at ca. 108 mm diameter (scale bar = 15 mm); GZN2010I 245. H. Ribbing pattern on left flank at ca. 108 mm diameter (scale bar = 10 mm); GZN2010I 245. I. Ribbing pattern on left flank at ca. 65 mm diameter (scale bar = 10 mm); GZN2010I 261.

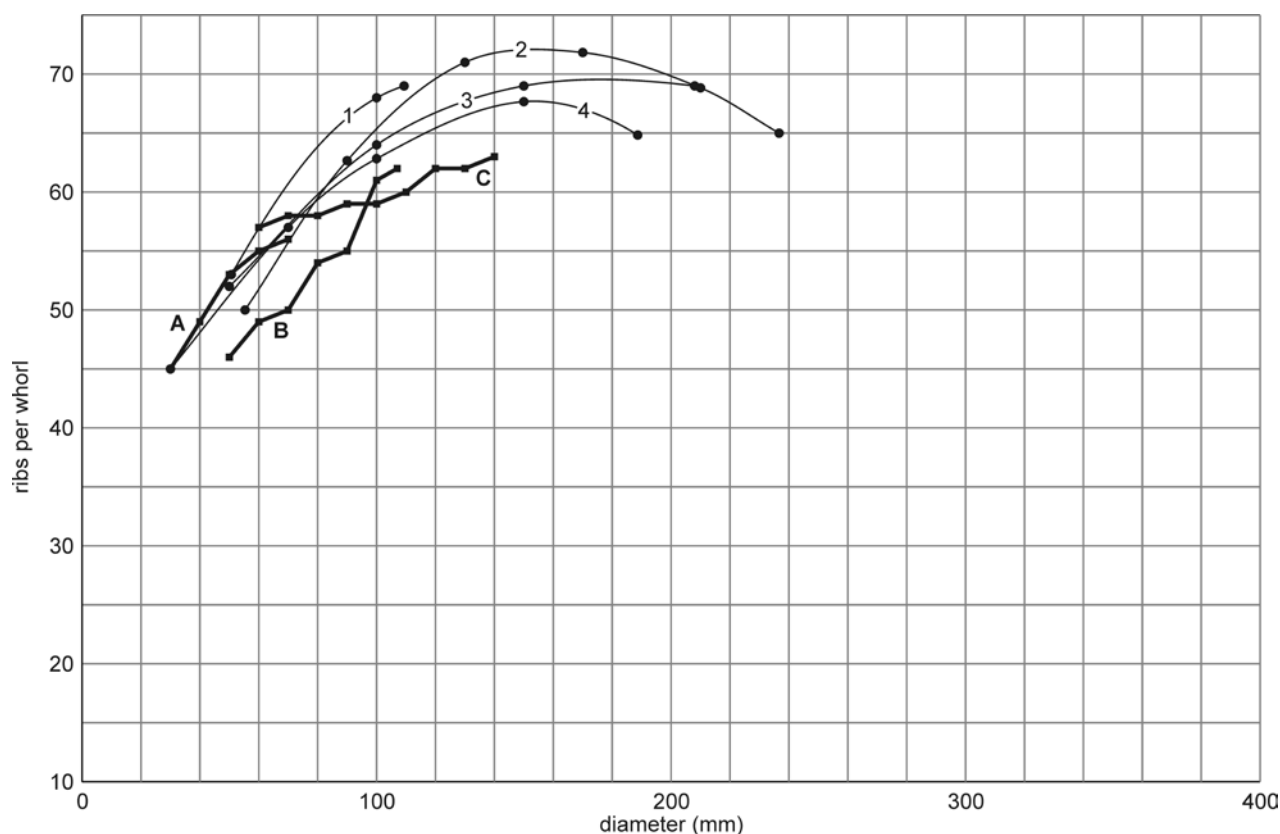


Fig. 34: Rib curves of specimens of *Perisphinctes* (*Liosphinctes*) *plicatilis* (J. SOWERBY, 1817) from the Kachchh Basin (A: GZN2010I 261; B: GZN2010I 245; C: GZN2010I 165) compared to previously published curves of this species (1: holotype, ARKELL, 1939, textfig. 41; 2, 4: ENAY, 1966, textfig. 117, no. 1, 2; 3: topotype, ARKELL, 1939, textfig. 41).

of gradually varicostate, very fine to fine, closely spaced (Fig. 34), prorsiradiate primary ribs originating either at the umbilical suture or near the umbilical margin in a rursiradiate fashion to turn prorsiradiate on the flank. Primaries branch into two secondaries at the ventrolateral shoulder on inner whorls and at slightly above or around mid-lateral height on outer whorls. Secondaries cross the venter with slightly forward-directed convexity. Umbilical wall distinct, gradually merging with flanks at the rounded umbilical margin. Constrictions present, numbering at least three per whorl.

Remarks: The specimens range in size from small to large, but represent only phragmocones. The suture lines are well preserved. The constrictions are easily traceable on the inner whorls. The evolution and ribbing pattern match *P. (Arisphinctes) plicatilis* as described by ARKELL (1939; compare Fig. 34). The specimens described as *Perisphinctes plicatilis* (J. SOWERBY) by WAAGEN (1875c, p. 189) have a wider umbilicus at comparable shell diameters and have been excluded from synonymy [*P. (A.) kachchhensis*, see above]. *Perisphinctes chloroolithicus* (non GÜMBEL) described by WAAGEN (1875c, p. 198, pl. 50, fig. 3a, b; also see SPATH, 1931a, p. 454; = *Lithacoceras submazuricum*) has a smaller umbilicus than the specimens described by ARKELL (1938, p. 95, pl. 18, figs. 1-7) under this name. *Perisphinctes* cf. *kiliani* DE RIAZ figured by KRISHNA *et al.* (1996b, pl. 1, fig. 2) is similar to the present specimens with respect to their gradually varicostate, very fine to fine, closely spaced, prorsiradiate ribs and general shell coiling. ENAY (1966, p. 363) included this species (with sign of interrogation) in *Perisphinctes (Arisphinctes)* cf. *chloroolithicus* (GÜMBEL), which has a lower number of ribs than *plicatilis*.

The ornamentation and dimensions of *Dichotomosphinctes falculae* (RONCHADZÉ) as described by SPATH (1931a, p. 435, pl. 68, fig. 7) are also comparable. Previous workers such as SPATH (1931a) and ARKELL (1937, p. liv; 1938: p. 82) always regarded *Perisphinctes falculae* (RONCHADZÉ) as a nucleus or small specimen.

The specimen GZN2010I 256 shows resemblance to *Larcheria subschilli* (LEE) (ENAY, 1966, p. 530, pl. 35, figs. 1, 2, pl. 36), but the flanks of specimen GZN2010I 256 are slightly arched, unlike in *Larcheria subschilli*.

The ribbing density of specimen GZN2010I 165 increases less rapidly than other members of this species (Fig. 34C), but can still be considered to lie within the natural variability of the species.

Subgenus *Dichotomosphinctes* BUCKMAN, 1926

Type species: *Perisphinctes antecedens* SALFELD, 1914.

Remarks: Small to medium in size, evolute, whorl section rounded to compressed to depressed; ornamentation of fine ribs up to the end of the body chamber (iso- or varicostate), with constrictions and lappets.

Perisphinctes sp. cf. *Perisphinctes* (*Dichotomosphinctes*) *antecedens* SALFELD, 1914 Pl. XI, figs. 1, 2; Fig. 35; Tab. 20

- cf. 1959b. *Dichotomosphinctes antecedens* SALFELD. – COLLIGNON, pl. 56, fig. 271.
- cf. 1966. *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD. – ENAY, p. 470, pl. 28, figs. 1-4, textfigs. 138, 3-4, 139-143.
- cf. 2000. *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD. – GYGI, p. 82, pl. 3, fig. 4, textfig. 44.
- cf. 2001. *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD. – GYGI, p. 45, figs. 62, 63, p. 67, figs. 98, 99.

Material: Four specimens. Two specimens from the Dhosa Conglomerate Bed of the Jara Dome (GZN2009II 194, OUMNH JY.479). One specimen from the Dhosa Conglomerate Bed of the Jumara Dome (GZN2010I 1055). One specimen from the Dhosa Conglomerate Bed close to Medisar, Jhura Dome (GZN2009II 013).

Description: Specimens small, fragments of phragmocones. Whorl section subrounded (inner whorls) to oval (outer whorls; Fig. 35), slightly compressed with maximum thickness of the whorl slightly above the umbilical margin. Ornamentation consists of gradually varicostate, very fine (inner whorls) to moderately coarse and distant (outer whorls) primary ribs, originating at the umbilical suture in a slightly rursiradiate fashion, bending forwards on the rounded umbilical margin, and running prorsiradiately on the slightly arched (inner whorls) to flat flanks (outer whorls). Primaries branch into two or three secondaries, the third being mostly free, slightly below the ventrolateral shoulder. Occasionally secondaries of one primary connect with two adjacent primaries on the other side of the specimen ("galloping"). Secondaries cross the venter with slight forward-directed convexity. Constrictions present.

Remarks: The combination of ornamentation, ratio between whorl height and thickness, as well as the shape

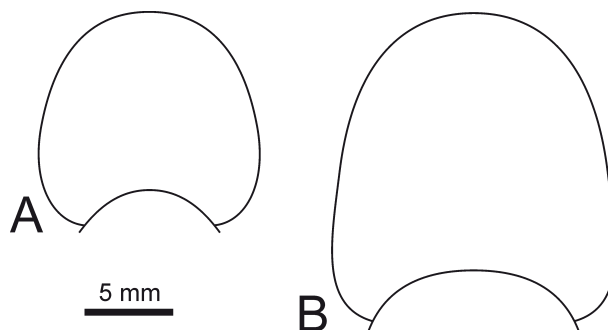


Fig. 35: *Perisphinctes* sp. cf. *Perisphinctes (Dichotomosphinctes) antecedens* SALFELD, 1914; Dhosa Conglomerate Bed, Medisar, Jhura Dome (A) and Jara Dome (B). A. Whorl section at ca. 36 mm diameter; GZN2009II 013. B. Whorl section at ca. 55 mm diameter; GZN2009II 194.

of the whorl section does not match any of the species previously described from Kachchh. *Perisphinctes* (*Dichotomosphinctes*) *antecedens* SALFELD is the nearest comparable taxon.

***Perisphinctes* (*Dichotomosphinctes*) *elisabethae*
DE RIAZ, 1898**

Pl. XII, figs. 1-3; Figs. 36, 37; Tab. 21

1898. *Perisphinctes elisabethae* DE RIAZ, p. 22, pl. 12, figs. 4, 5.
1966. *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ. – ENAY, p. 490, pl. 30, figs. 4, 5, pl. 31, figs. 2-6, textfigs. 148, 150.
2000. *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ. – GYGI, p. 83, pl. 3, fig. 5, textfig. 45.
2001. *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ. – GYGI, p. 72, figs. 106, 107, p. 127, figs. 178-182.

Material: Four specimens. Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 094, 100). Two specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 137, 146).

Description: Shells moderately large, partly with beginning body chamber, evolute, compressed. Whorl

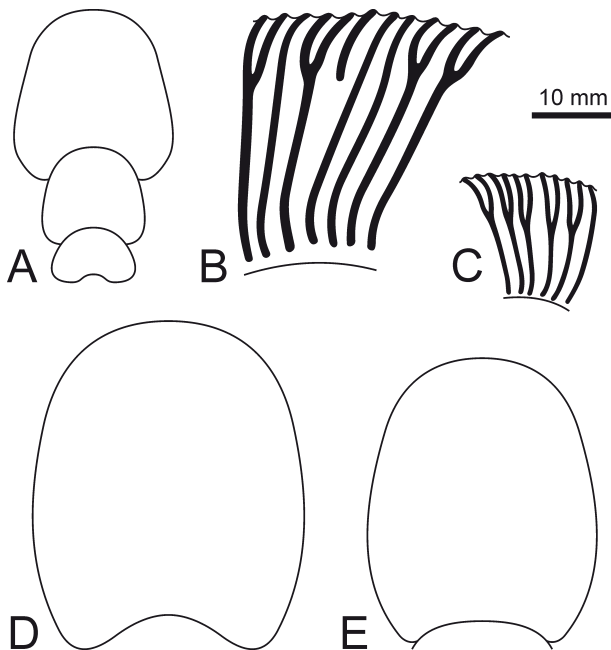


Fig. 36: *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ, 1898; Kantkote Ammonite Beds, Kantkote Village (A, B, E) and Trama River (C, D). A. Cross section at ca. 68 mm diameter; GZN2010I 100. B. Ribbing pattern on right flank at unknown diameter; GZN2010I 094. C. Ribbing pattern on left flank at unknown diameter; GZN2010I 137. D. Whorl section at unknown diameter; GZN2010I 146. E. Whorl section at unknown diameter; GZN2010I 094.

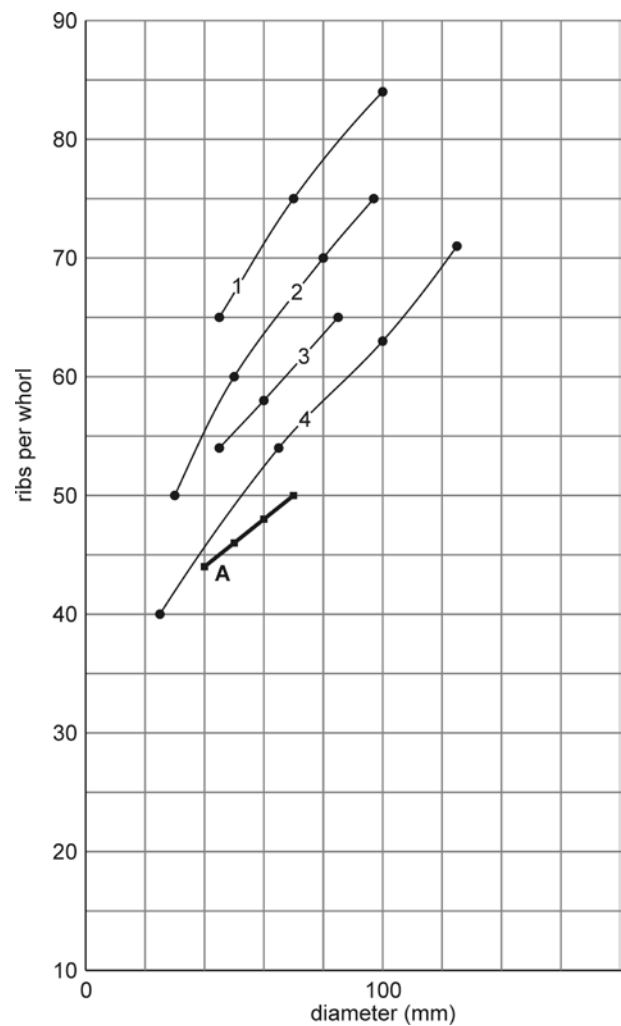


Fig. 37: Rib curve of *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ, 1898 from the Kachchh Basin (A: GZN2010I 094) compared to previously published curves of this species (1: syntype, ENAY, 1966, textfig. 150; 2, 4: ENAY, 1966, textfig. 150, no. 5, 2; 3: lectotype, ENAY, 1966, textfig. 150).

section oval with maximum thickness between mid-flank to close to umbilical margin (Fig. 36A, D, E). Ornamentation consists of thin to moderately thick, long, prorsiradiate primary ribs, originating at the umbilical suture in a slightly rursiradiate fashion and turning forward along the subrounded umbilical margin. Primaries bifurcate slightly below the ventrolateral shoulder on inner whorls and still lower on the outer whorl (Fig. 36B, C). Secondary ribs cross the venter with pronounced forward-directed convexity. Undivided primaries and free secondaries with irregular space between them common on body chamber. Ribbing density increases steeply during ontogeny, but the actual number of ribs per whorl and diameter can vary considerably (Fig. 37). Constrictions present on inner whorls, but rather indistinct on outer whorls.

Remarks: The specimens match *Perisphinctes* (*Dichoto-*

mosphinctes) *elisabethae* DE RIAZ. The modification of the ribbing on the outer whorl of specimen GZN2010I 094 marks the appearance of the peristome, which, however, is not preserved (Pl. XII, fig. 2). The ornamentation of the inner whorls is also comparable to *P. (Liosphinctes) plicatilis* (J. SOWERBY), as described above. The style of ornamentation in the present specimens is also relatively similar to the specimens GZN2010I 141 and GZN2010I 135 described below as *P. (Dichotomosphinctes) gr. crassus* and *P. (Dichotomosphinctes) stenocycloides* SIEMIRADZKI, respectively. *Perisphinctes leiocymon* WAAGEN (1875c, p. 205, pl. 52, fig. 1, 1a) is a comparable species described from a red iron rock at Kantkote. The species has been described by WAAGEN (1875c) as being very compressed (“about twice as high as broad”). However, WAAGEN (1875c) gives dimensions contradicting this statement. In the present specimens the primary ribs are longer and branch higher than in *P. leiocymon* WAAGEN.

Perisphinctes (Dichotomosphinctes) aff. gamelai

ARKELL, 1947

Pl. XII, figs. 4, 5; Fig. 38; Tab. 22

aff. 1947b. *Perisphinctes (Dichotomosphinctes) gamelai* ARKELL, p. 358, pl. 75, figs. 3-5.

Material: One specimen from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 109).

Description: Shell small, evolute, and almost complete, with at least half the body chamber preserved. Whorl section compressed and suboval (Fig. 38A). Ornamentation consists of very fine to fine, closely but irregularly spaced, prorsiradiate primary ribs, originating near the umbilical margin nearly rursiradiate, turning prorsiradiate just beyond the umbilical margin. Across the flank they run faintly sinuously, branching slightly below the ventrolateral shoulder (Fig. 38B). Occasionally, undivided single primaries cross the venter and end as free secondaries on the other side. The posterior secondary branches off in a slightly backward direction. Secondaries cross the venter with slight forward-directed convexity. Umbilical wall more or less smooth. Constrictions indistinct.

Remarks: This is a small specimen which does not show a suture line on the outer whorl. Some traces of suture lines can be seen on the inner, sparite-filled whorls. The dimensional proportions, irregular spacing of the ribs, undivided primaries, and compressed whorl section resembles *Perisphinctes (Dichotomosphinctes) elisabethae* DE RIAZ as described above. However, the ribs are distinctly finer in the present specimen. Constrictions are not very conspicuous and can be traced best on the basis of the irregular spacing of the adjacent primary ribs. The morphological characters of the present specimen, such as the suboval whorl section and the prorsiradiate, fine, and dense ribs bifurcating near the ventrolateral

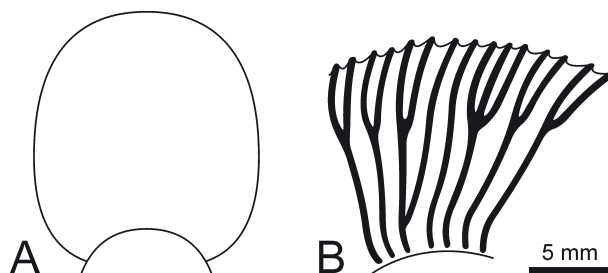


Fig. 38: *Perisphinctes (Dichotomosphinctes) aff. gamelai* ARKELL, 1947; Kantkote Ammonite Beds, Kantkote Village; GZN2010I 109. A. Whorl section at ca. 44 mm diameter. B. Ribbing pattern on right flank at ca. 35 mm diameter.

region with the posterior secondary being backward-directed closely match those of *P. (Dichotomosphinctes) gamelai* as described by ARKELL (1947b). Due to the poor state of preservation and absence of information on the outer whorl, the specimen has been assigned to the species tentatively.

***Perisphinctes (Dichotomosphinctes) jacki*
(SPATH, 1931)**

Pl. XII, figs. 8-13; Figs. 39, 40; Tab. 23

1931a. *Otosphinctes jacki* SPATH, p. 414, pl. 70, figs. 2a, b, 4, pl. 73, fig. 6, pl. 74, fig. 4a, b (holotype).

Material: Nineteen specimens. Three specimens from the Dhosa Oolite (OUMNH JY.272, JY.273, JY.275) and twelve specimens from the Dhosa Conglomerate Bed (GZN2009II 005, 024, 115-117, 193, 231, GZN2010I 1084, 1086, OUMNH JY.473, JY.481, JY.530) of the Jara Dome. One specimen from the Dhosa Oolite (GZN2009II 074) and one specimen from the Dhosa Conglomerate Bed (GZN2010I 1051) of the Jumara Dome. One specimen from the Dhosa Conglomerate Bed near Medisar, Jhura Dome (GZN2009II 118). One specimen from the Dhosa Conglomerate Bed near Samatra, south of Bhuj (OUMNH JY.1137/1-2).

Description: Shells small to moderately large, incomplete, septate till end, evolute, depressed innermost whorls to compressed outer whorls. Whorl section subquadrangular with nearly flat flanks to oval (Fig. 39A-D). Maximum thickness at about one-fourth of whorl height, flanks grade smoothly into the moderately arched venter. Umbilical wall short, moderately distinct. Ornamentation consists of isocostate, prorsiradiate, sharp primary ribs originating near the umbilical suture with rectiradiate orientation then turning prorsiradiate near the umbilical margin. Primaries branch regularly into two slightly finer secondaries at the ventrolateral region (Fig. 39E). Occasionally undivided primaries occur. Commonly, secondaries of a primary rib are connected to two adjacent primary ribs on the other side (“galloping”).

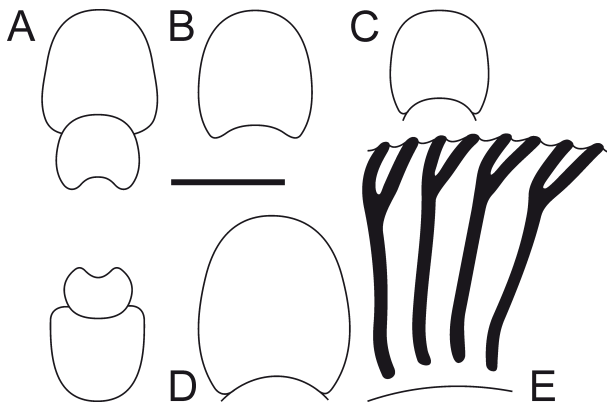


Fig. 39: *Perisphinctes* (*Dichotomosphinctes*) *jacki* (SPATH, 1931); Dhosa Conglomerate Bed, Jara Dome (A, C) and Jumara Dome (B), Dhosa Oolite, Jumara Dome (D, E). A. Cross section (scale bar = 15 mm); GZN2009II 117. B. Whorl section at unknown diameter (scale bar = 15 mm); GZN2010I 1051. C. Whorl section at ca. 43 mm diameter (scale bar = 15 mm); GZN2009II 005. D. Whorl section at ca. 85 mm diameter (scale bar = 15 mm); GZN2009II 074. E. Ribbing pattern on right flank at ca. 81 mm diameter (scale bar = 10 mm); GZN2009II 074.

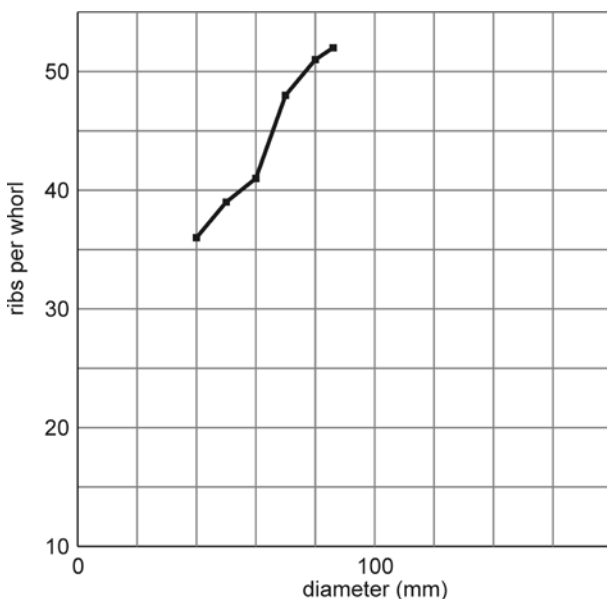


Fig. 40: Rib curve of *Perisphinctes* (*Dichotomosphinctes*) *jacki* (SPATH, 1931) from the Kachchh Basin (GZN2009II 074).

Secondaries cross the venter with slight forward-directed convexity. Ribbing density is moderate, increasing continuously from diameters of 40 to about 90 mm (Fig. 40). Constrictions distinct, numbering two to three per whorl.

Remarks: The present specimens are incomplete phragmocones representing inner whorls. The holotype

of *Otosphinctes jacki* SPATH (1931a, p. 414, pl. 74, fig. 4a, b) is also represented by a phragmocone, but is slightly larger than the present specimens. There is a good resemblance in ornamentation and proportional dimensions between this species and *Grossouvria evexa* (QUENSTEDT) (SPATH, 1931a, p. 367).

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from Badi (Jhura Dome), Habae (Habo Dome), Fakirwari, Ler, and Wanda (most likely from Dhosa Oolite). Doubtful specimens were recorded from the Jumara Dome, South Manjal, Keera Dome, and the Charwar Hills.

***Perisphinctes* (*Dichotomosphinctes*) cf. *obliqueplicatus* WAAGEN, 1875**

Pl. XIII, figs. 1-4, 6; Figs. 41, 42; Tab. 24

cf. 1875c. *Perisphinctes obliqueplicatus* WAAGEN, p. 187, pl. 45, fig. 4a, b, pl. 48, fig. 2a, b (lectotype).

cf. 1931a. *Alligaticeras obliqueplicatum* (WAAGEN). – SPATH, p. 407, pl. 72, fig. 3.

cf. 1959a. *Alligaticeras* aff. *obliqueplicatum* (WAAGEN). – COLLIGNON, pl. 41, figs. 211, 212.

Material: Five specimens. One specimen from the Dhosa Conglomerate Bed of the Jara Dome (GZN2009II 202). One specimen from the Dhosa Conglomerate Bed close to Kamaguna, Jhura Dome (GZN2009II 189). One specimen from the Dhosa Conglomerate Bed close to Jhura Camp, Jhura Dome (GZN2009II 119). One specimen from the Dhosa Oolite at Rudra Mata, Habo Dome (GZN2009II 028). One specimen from the southernmost tip of Khadir Island (OUMNH JY.1159).

Description: Shells small to large, evolute, septate till end, compressed. Whorl section suboval with faintly arched flanks merging smoothly into well rounded venter (Fig. 41A-C). Umbilical wall feebly arched to indistinct, merging gradually into flanks. Ornamentation consists of gradually varicostate, fine primary ribs originating near the umbilical margin with prorsiradial orientation running consistently forwardly inclined across the flank. Primaries branch regularly into two finer secondaries near the ventrolateral region and cross the venter with slight forward-directed convexity (Fig. 41D, E). Ribbing density is moderate, increasing steeply from diameters of 30 to 70 mm (Fig. 42). Constrictions distinct, numbering at least two per whorl. Suture lines closely spaced at the mature stage.

Remarks: *Perisphinctes obliqueplicatus* WAAGEN (1875c, p. 187) shows similar proportional dimensions, ornamentation, and whorl section. The largest, but poorly preserved specimen (GZN2009II 028) shows at least five whorls with prorsiradial ribs. WAAGEN (1875c) already mentioned that *Perisphinctes* (*Dichotomosphinctes*) *obliqueplicatus* is smaller in size than the closely related *Perisphinctes* (*Dichotomosphinctes*) *rota*, but in addition, it is also much more densely ribbed.

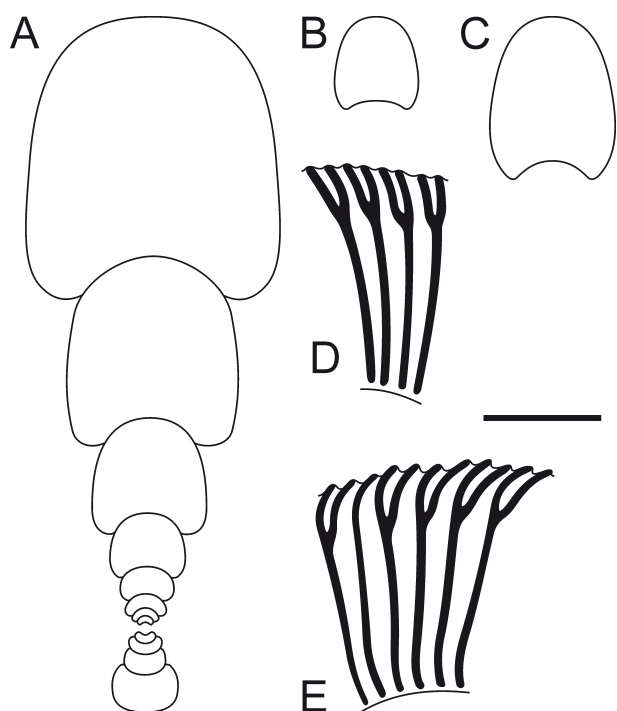


Fig. 41: *Perisphinctes* (*Dichotomosphinctes*) cf. *obliqueplicatus* WAAGEN, 1875; Dhosa Oolite, Rudra Mata, Habo Dome (A), Dhosa Conglomerate Bed, Jara Dome (B-D) and Kamaguna, Jhura Dome (E). A. Cross section (scale bar = 15 mm); GZN2009II 028. B. Whorl section at unknown diameter (scale bar = 15 mm); GZN2009II 202. C. Whorl section at unknown diameter (scale bar = 15 mm); GZN2009II 202. D. Ribbing pattern on left flank at unknown diameter (scale bar = 10 mm); GZN2009II 202. E. Ribbing pattern on right flank at ca. 61 mm diameter (scale bar = 10 mm); GZN2009II 189.

The fine, closely spaced ornamentation and estimated proportional dimensions of specimen GZN2009II 202 are also similar to *Lithacoceras submazurium* SPATH (1931a, p. 454, pl. 68, figs. 6a, b), but the ventral, forward-directed convexity of the secondaries is absent in *submazurium*.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described this species from the Dhosa Oolite of the Jara Dome (northwest of Soorka) and Wanda. SPATH (1931a) mentioned the species from the Dhosa Oolite of Jumara and Keera domes, from Niruna and Kamaguna (both Jhura Dome), Samatra, and Fakirwari.

Perisphinctes* (*Dichotomosphinctes*) *rotiformis
(SPATH, 1931)

Pl. XIV, fig. 2; Fig. 43; Tab. 25

- aff. 1875c. *Perisphinctes rota* WAAGEN, p. 186, pl. 48, fig. 1a, b.
1875c. *Perisphinctes indogermanus* WAAGEN, p. 185, pl. 48, fig. 4 only (= holotype of *Perisphinctes* (*Dichotomosphinctes*) *rotiformis*).

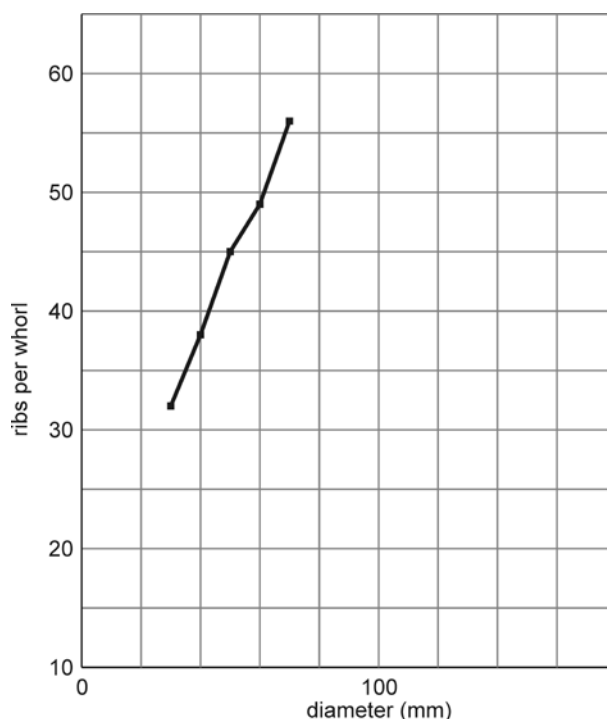


Fig. 42: Rib curve of *Perisphinctes* (*Dichotomosphinctes*) cf. *obliqueplicatus* WAAGEN, 1875 from the Kachchh Basin (GZN2009II 189).

- aff. 1931a. *Otosphinctes rota* (WAAGEN). – SPATH, p. 410, pl. 72, fig. 8a, b.
1931a. *Otosphinctes rotiformis* SPATH, p. 412, pl. 73, fig. 1a, b, pl. 92, fig. 8.
1959a. *Dichotomosphinctes* (*Otosphinctes*) *rotiformis* SPATH. – COLLIGNON, pl. 42, fig. 214.

Material: Three specimens. One specimen from the Dhosa Oolite (GZN2009II 067) and one specimen from the Dhosa Conglomerate Bed (GZN2009II 232) of the Jara Dome. One specimen from the southernmost tip of Khadir Island (GZN2011I 331).

Description: Shell moderately large, incomplete, evolute, depressed (Fig. 43A). Whorl section subquadrangular (Fig. 43B) with arched flanks and maximum thickness at mid height. Flanks merge smoothly into a moderately arched venter. Ornamentation consists of isocostate, sharp, prorsiradiate, primary ribs which run across the flank with slight backward-directed convexity and branch into two secondaries at the ventrolateral region. Secondaries cross the venter with slight forward-directed convexity. Constrictions distinct.

Remarks: Specimen GZN2009II 067 seems to show parts of the body chamber. The estimated proportional dimensions suggest that the width of the umbilicus decreases and whorl height increases with growth. The specimen matches well the figure given by SPATH (1931a). *P.* (*Dichotomosphinctes*) *rotiformis* is considered to be the microconch to *P.* (*Arisphinctes*) *rota*, described above.

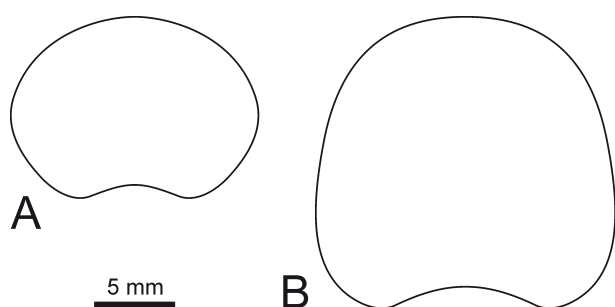


Fig. 43: *Perisphinctes* (*Dichotomosphinctes*) *rotiformis* (SPATH, 1931); Dhosa Oolite, Jara Dome; GZN2009II 067. A. Whorl section at ca. 43 mm diameter. B. Whorl section at unknown diameter.

Earlier records from the Kachchh Basin: The specimens described by WAAGEN (1875c) and later identified as *Otosphinctes rotiformis* by SPATH (1931a) were collected from the Dhosa Oolite of the Keera Dome and Wanda. Additionally, SPATH (1931a) mentions the species from the Dhosa Oolite of the Jumara Dome with more doubtful specimens from the Jhura Dome (e.g. Badi), Samatra, Fakirwari, and Ler.

***Perisphinctes* (*Dichotomosphinctes*) *subhelenae* (SPATH, 1931)**

Pl. XIV, figs. 8, 9; Figs. 44, 45; Tab. 26

1931a. *Dichotomosphinctes subhelenae* SPATH, p. 437, pl. 87, fig. 10a, b, pl. 101, figs. 2, 3, 10 (non pl. 101, fig. 4a, b).

Material: Fourteen specimens. Three specimens from the Dhosa Conglomerate Bed close to Kotai, Habo Dome (OUMNH JY.1260, JY.1261/1, JY.1261/2). Eight specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 151, 162, 184, 190, 200, 209, 222, 224). One stray specimen from the Trama River, Wagad Uplift (GZN2010I 232). Two stray specimens with unknown locality (GZN2010I 259, 262).

Description: Shells moderately large, incomplete, septate till end, and evolute. Whorl section compressed, the slightly arched flanks merge into the rounded venter with smooth curve (Fig. 44A-D). Ornamentation consists of gradually varicostate, moderately coarse, sharp, prorsiradiate primary ribs which bifurcate at the ventrolateral region (Fig. 44E). Primaries originate at the umbilical suture rursiradiately. Secondaries cross the venter with forward-directed convexity. Ribbing density is moderate to dense, increasing considerably from diameters of 30 to 100 mm (Fig. 45). Umbilical wall short, distinct.

Remarks: Most of the present specimens have been collected from the Trama River section and show similar proportional dimensions as the specimens described as *Perisphinctes* (*Arisphinctes*) *chloroolithicus* (GÜMBEL)

from the same locality (see above). However, the flanks in the present specimens are flat, while in *chloroolithicus* they are slightly arched. This character, together with the proportional dimensions and ornamentation, supports an identification of the present specimens as *Perisphinctes* (*Dichotomosphinctes*) *subhelenae* (SPATH). SPATH

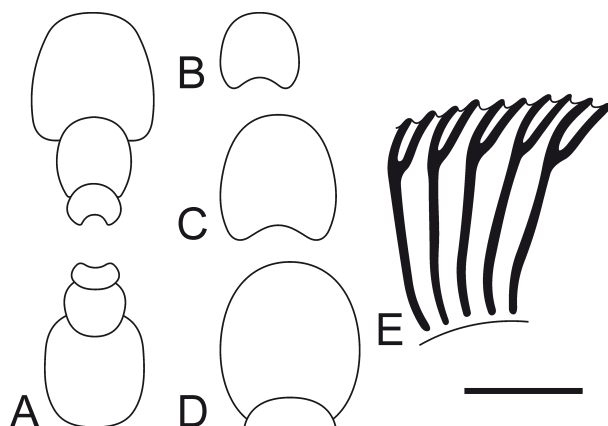


Fig. 44: *Perisphinctes* (*Dichotomosphinctes*) *subhelenae* (SPATH, 1931); Kantkote Ammonite Beds, Trama River. A. Cross section (scale bar = 15 mm); GZN2010I 151. B. Whorl section at ca. 28 mm diameter (scale bar = 15 mm); GZN2010I 190. C. Whorl section at ca. 50 mm diameter (scale bar = 15 mm); GZN2010I 190. D. Whorl section at ca. 71 mm diameter (scale bar = 15 mm); GZN2010I 190. E. Ribbing pattern on right flank at ca. 93 mm diameter (scale bar = 10 mm); GZN2010I 184.

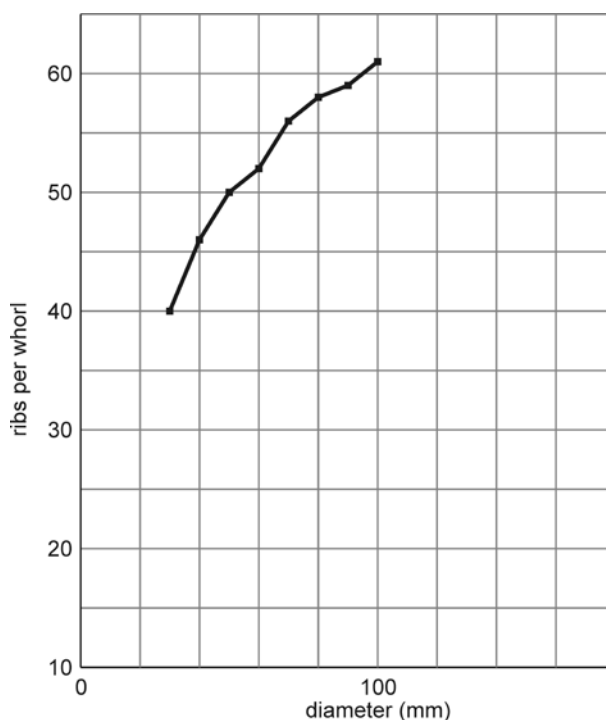


Fig. 45: Rib curve of *Perisphinctes* (*Dichotomosphinctes*) *subhelenae* (SPATH, 1931) from the Kachchh Basin (GZN1010I 184).

(1931a) illustrated a compressed (pl. 101, fig. 2) and a less compressed variety (pl. 101, fig. 10). One of the specimens of this species figured by SPATH (1931a, pl. 101, fig. 4b), does not show the forward-directed convexity of secondary ribs on the venter and has therefore been excluded from synonymy.

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite of the Jumara Dome and Niruna (Jhura Dome).

***Perisphinctes (Dichotomosphinctes) cf. subhelenae*
(SPATH, 1931)**

Tab. 27

cf. 1931a. *Dichotomosphinctes subhelenae* SPATH, p. 437, pl. 87, fig. 10a, b, pl. 101, figs. 2, 3, 10 (non pl. 101, fig. 4a, b).

Material: Three specimens from the Dhosa Conglomerate Bed of the Jara Dome (GZN2009II 004, GZN2010I 1076, 1080).

Description: Shells small to moderately large, incomplete, evolute. Whorl section depressed and rounded in inner whorls, compressed and subrectangular with more or less parallel flanks in outer whorls. Flanks merge smoothly into the venter in inner whorls and display an obtusely rounded ventrolateral shoulder in outer whorls. Ornamentation consists of moderately coarse, prorsiradiate ribs, bifurcating at the ventrolateral shoulder. Secondaries cross the venter with slight forward-directed convexity.

Remarks: These are fragments of inner whorls. Compared to the specimens described above as *Perisphinctes (Arisphinctes) cf. trifidus* (J. SOWERBY) they are more compressed and have a subrectangular whorl section. The ribs are coarser than on the inner whorls of the specimens described as *Perisphinctes (Dichotomosphinctes) cf. obliqueplicatus* WAAGEN.

Earlier records from the Kachchh Basin: SPATH (1931a) described the species from the Dhosa Oolite of the Jumara Dome and Niruna (Jhura Dome).

***Perisphinctes (Dichotomosphinctes) aff. wartae*
BUKOWSKI, 1887**

Pl. XIV, figs. 6, 7; Tab. 28

- aff. 1887. *Perisphinctes wartae* BUKOWSKI, p. 140, pl. 27, fig. 1.
1959b. *Dichotomosphinctes wartae* BUKOWSKI var. *bedoensis* COLLIGNON, pl. 61, fig. 281.
aff. 1966. *Perisphinctes (Dichotomosphinctes) wartae* BUKOWSKI. – ENAY, p. 483, pl. 30, figs. 1-3, textfigs. 140, 146, 147.
aff. 2009b. *Dichotomoceras wartae* (BUKOWSKI). – KRISHNA *et al.*, pl. 2, figs. 1a, b, 2a, b, 3a, b.

Material: One specimen from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (OUMNH JY.1166).

Description: Shell moderately large, incomplete, evolute, compressed. Whorl section suboval, maximum inflation at one-third of whorl height. Ornamentation consists of prorsiradiate, moderately coarse, sharp, and sparse primary ribs originating near the umbilical suture rather rursiradiately. Primaries cross the rounded umbilical margin more or less straight and branch at three-quarters of whorl height into two secondary ribs. Occasionally single, undivided primaries present, demarcating shallow constrictions. Secondaries cross the venter with distinct forward-directed convexity.

Remarks: This is a fragmentary specimen in which suture lines could not be observed on the outer whorl. The latter possibly represents part of the body chamber. The dimensional proportions and ornamentation match *P. (Dichotomosphinctes) wartae* as illustrated by COLLIGNON (1959b). The primary ribs of the specimens described as *P. (D.) wartae* by BUKOWSKI (1887) and ENAY (1966) are branching slightly higher, at the ventrolateral shoulder. Based on the single specimen in the present collection, it cannot be decided, whether this difference falls within the intraspecific variability of the species or qualifies for the erection of a new taxon. For now, it has been therefore placed into the affinity of *P. (D.) wartae*. The present specimen can be differentiated from *Perisphinctes* sp. cf. *Perisphinctes (Dichotomosphinctes) wartae* described below on the basis of its arched flanks and lower branching of ribs.

***Perisphinctes* sp. cf. *Perisphinctes*
(*Dichotomosphinctes*) *wartae* BUKOWSKI, 1887
Pl. XIV, figs. 3-5; Fig. 46; Tab. 29**

- cf. 1887. *Perisphinctes wartae* BUKOWSKI, p. 140, pl. 27, fig. 1.
cf. 1966. *Perisphinctes (Dichotomosphinctes) wartae* BUKOWSKI. – ENAY, p. 483, pl. 30, figs. 1-3, textfigs. 140, 146, 147.
cf. 2009b. *Dichotomoceras wartae* (BUKOWSKI). – KRISHNA *et al.*, pl. 2, figs. 1a, b, 2a, b, 3a, b.

Material: Two specimens from the Dhosa Conglomerate Bed of the Jara Dome (GZN2009II 237, GZN2010I 1077).

Description and remarks: These are small fragments of evolute phragmocones. Their whorl section is suboval and compressed (Fig. 46A, B). Ornamentation consists of long, slightly prorsiradiate, moderately sharp, distant primary ribs, bifurcating at the ventrolateral shoulder (Fig. 46C, D). Secondaries cross the venter with slight forward-directed convexity. The ornamentation, whorl section, and ratio between whorl height and thickness match *P. (Dichotomosphinctes) wartae*. Due to their fragmented nature, however, we refrain from a precise identification.

Earlier records from the Kachchh Basin: KRISHNA *et al.* (2009b) described the species from the Wagad Uplift, close to Kantkote Village.

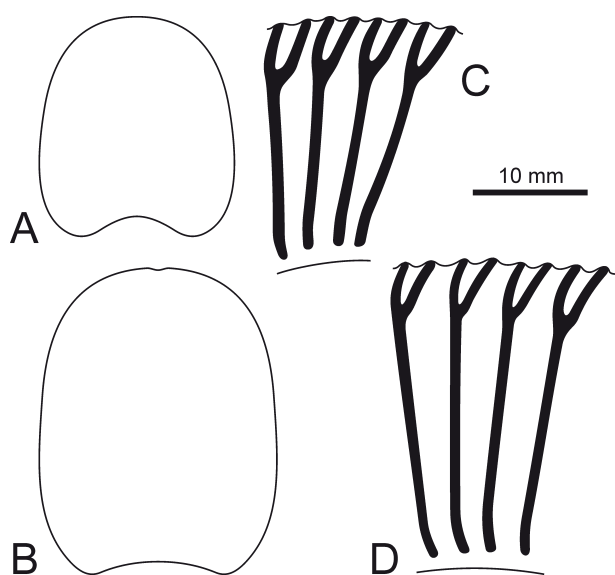


Fig. 46: *Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomosphinctes*) *wartae* BUKOWSKI, 1887; Dhosa Conglomerate Bed, Jara Dome. A. Whorl section at unknown diameter; GZN2009II 237. B. Whorl section at unknown diameter; ZN2010I 1077. C. Ribbing pattern on right flank at unknown diameter; GZN2009II 237. D. Ribbing pattern on right flank at unknown diameter; ZN2010I 1077.

***Perisphinctes* (*Dichotomosphinctes*) aff. *lehmani*
(COLLIGNON, 1959)**

Pl. VIII, fig. 1; Fig. 47; Tab. 30

- aff. 1959b. *Orionoides lehmani* COLLIGNON, pl. 59, fig. 276, pl. 60, fig. 277.
1996b. *Perisphinctes* (*Beraketites*) cf. *lehmani* COLLIGNON. – KRISHNA *et al.*, pl. 1, fig. 3.

Material: One specimen from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 144).

Description: Shell small, incomplete, evolute, depressed. Whorl section rounded with uniformly arched flanks and venter (Fig. 47A). Ornamentation consists of thick, prorsiradiate primary ribs branching into two or three finer secondaries at the ventrolateral region (Fig. 47B), which cross the venter either straight or with very faint backward-directed convexity. Constrictions deep, forwardly inclined.

Remarks: The phragmocone is completely filled with sparite, whereas the last three quarters of the whorl are body chamber. A deep constriction at the end of the last whorl is well preserved. The ornamentation and general morphology of the shell match a specimen from the Kachchh Basin identified as *Perisphinctes* (*Beraketites*) cf. *lehmani* (COLLIGNON) by KRISHNA *et al.* (1996b). Nevertheless, the Kachchh specimens differ from this species as illustrated by COLLIGNON (1959b) by being

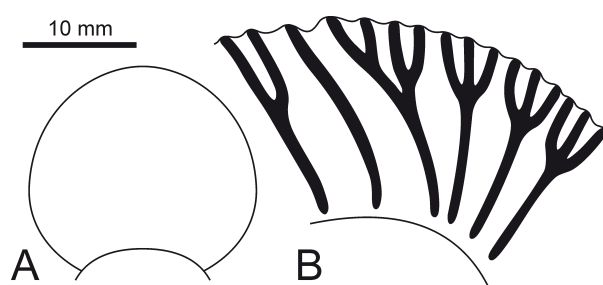


Fig. 47: *Perisphinctes* (*Dichotomosphinctes*) aff. *lehmani* (COLLIGNON, 1959); Kantkote Ammonite Beds, Trama River; GZN2010I 144. A. Whorl section at ca. 61 mm diameter. B. Ribbing pattern on left flank at ca. 54 mm diameter.

more involute and therefore have been placed only in its affinity. The status of the subgenus *Beraketites* seems to be unclear (compare ENAY, 1966, p. 446); instead, the general morphology of the present specimens supports their inclusion into the subgenus *Dichotomosphinctes*.

Earlier records from the Kachchh Basin: KRISHNA *et al.* (1996b) recorded and figured the species from the Wagad Uplift.

***Perisphinctes* (*Dichotomosphinctes*) aff. *aeneas*
GEMMELLARO, 1872**

Pl. XV, figs. 4–6; Figs. 48, 49; Tab. 31

- aff. 1872. *Perisphinctes aeneas* GEMMELLARO, p. 162, pl. 20, fig. 12.
1959b. *Discosphinctes aeneas* GEMMELLARO. – COLLIGNON, pl. 76, fig. 317 (non GEMMELLARO).
aff. 2008. *Perisphinctes* (*Subdiscosphinctes*) *aeneas* (GEMMELLARO). – OLÓRIZ *et al.*, p. 266, fig. 3c–h).

Material: Three specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 169, 208, 219).

Description: Shells small, incomplete, moderately evolute, planulate, compressed. Whorl section with slightly arched flanks and venter (Fig. 48A, B). Ornamentation consists of very fine, numerous, flexiprorsiradiate primary ribs bifurcating slightly below the distinct ventrolateral shoulder (Fig. 48C, D). Secondaries cross the venter with forward-directed convexity. Occasionally a single, undivided primary rib on one side is connected with a secondary rib on the other side (leading to “galloping” of secondaries). Constrictions present, indistinct.

Remarks: The specimens are similar to *Discosphinctes aeneas* as illustrated by COLLIGNON (1959b). There are only few further records of this species found in the literature (GEMMELLARO, 1872; OLÓRIZ *et al.*, 2008). COLLIGNON (1959b) assigned his specimens to *Discosphinctes*, but BROCHWICZ-LEWINSKI (1975), on the basis of his analysis of the temporal distribution of all Middle Oxfordian forms resembling *Lithacoceras* or

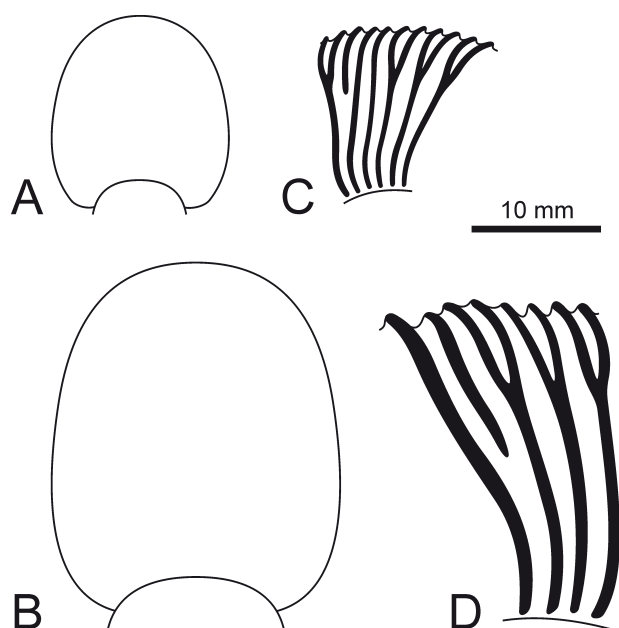


Fig. 48: *Perispinctes* (*Dichotomosphinctes*) aff. *aeneas* GEMMELLARO, 1872; Kantkote Ammonite Beds, Trama River. A. Whorl section at ca. 41 mm diameter; GZN2010I 219. B. Whorl section at ca. 78 mm diameter; GZN2010I 169. C. Ribbing pattern on right flank at ca. 33 mm diameter; GZN2010I 219. D. Ribbing pattern on left flank at ca. 77 mm diameter; GZN2010I 169.

Discosphinctes, suggested that they should be assigned to the subgenus *Subdiscosphinctes* MALINOWSKA. This subgenus was considered to comprise microconchs, while the associated macroconchs were grouped into the subgenus *Aureimontanites* (BROCHWICZ-LEWINSKI, 1975). However, the rib curve (Fig. 49) of *aeneas* does not match those of *Subdiscosphinctes* illustrated by MALINOWSKA (1972a, p. 172, fig. 2), but is closer to *Dichotomosphinctes*. The subgeneric assignment of the species has therefore been changed. The Madagascan Middle Oxfordian specimen described by COLLIGNON (1959b) appears to be a microconch and has a similar rib density as the present specimens. The illustration of the species by GEMMELLARO (1872, pl. 20, fig. 12) shows denser ribs and conspicuous constrictions. The specimen illustrated by OLÓRIZ *et al.* (2008, p. 266, fig. 3 c-h) is close to this species, shows similar ornamentation, but is much thicker.

The pattern and number of ribs at a comparable diameter are also similar to *Discosphinctes jelskii* described by ENAY (1966). However, ornamentation and whorl shape of specimens described as *Lithacoceras jelskii* (SIEMIRADZKI) by SPATH (1931a, p. 457, pl. 71, fig. 2a, b, pl. 78, fig. 5) and other indeterminate forms illustrated as *Lithacoceras* by SPATH (1931a, p. 457, pl. 66, fig. 7a, b) are also similar to the present specimens except for a generally lower point of bifurcation. Forms similar to *jelskii* are

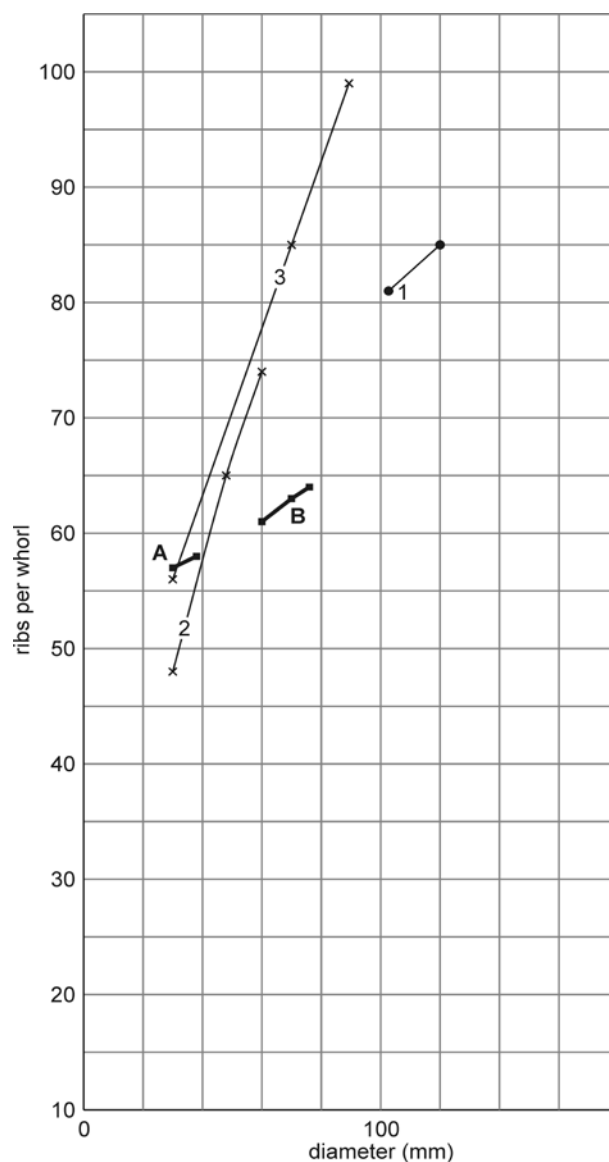


Fig. 49: Rib curves of specimens of *Perispinctes* (*Dichotomosphinctes*) aff. *aeneas* GEMMELLARO, 1872 from the Kachchh Basin (A: GZN2010I 219, B: GZN2010I 169) compared to a previously published curve of this species (1: holotype, ENAY, 1966, textfig. 168) and of *Subdiscosphinctes* (*Subdiscosphinctes*) *kreutzii* (SIEMIRADZKI, 1891) (2, 3: ENAY, 1966, textfig. 164, no. 2, 4).

known in the Kachchh Basin from Kimmeridgian strata (SPATH, 1931a, p. 458). *Lithacoceras* (*Discosphinctes*) *kreutzii* (SIEMIRADZKI) described by ENAY (1966, p. 537, pl. 37, figs. 5, 7) from the Middle Jurassic of France shows a similar ribbing pattern, but the ribs are finer and more dense (Fig. 49). Yet another specimen figured by SPATH (1931a, p. 456, pl. 87, fig. 9) as *Lithacoceras* aff. *kreutzii* (SIEMIRADZKI) from the Dhosa Oolite of the Jumara Dome does not differ in any essential character, but the specimen is too poorly preserved to be identified with confidence. The thickness and density of ribs at this

diameter is also similar to *Perisphinctes* (*Liosphinctes*) *plicatilis*, described above from the same stratigraphic level, but the inner whorls of *plicatilis* exhibit a greater whorl thickness and a more narrow umbilicus.

Perisphinctes* (*Dichotomosphinctes*) *tizianiformis

CHOFFAT, 1893

Pl. XV, figs. 11-13; Figs. 50B, C, 51; Tab. 32

1893. *Perisphinctes tizianiformis* CHOFFAT, p. 29, pl. 3, figs. 1-4.
 1898. *Perisphinctes tizianiformis* CHOFFAT. – SIEMIRADZKI, p. 253.
 1907. *Perisphinctes tizianiformis* CHOFFAT. – NEUMANN, p. 28.
 1907. *Perisphinctes tizianiformis* CHOFFAT. – OPPENHEIMER, p. 244.
 1994. *Orthosphinctes* (*Orthosphinctes*) *tizianiformis* (CHOFFAT). – SCHLEGELMILCH, p. 65, pl. 22, fig. 4.

Material: Three specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 149, 171, 243).

Description: Shells moderately large, evolute, compressed, complete with small lappets (Fig. 50C). Whorl section oval in outline with slightly arched flanks, which merge into the rounded venter (Fig. 50B). Ornamentation consists of isocostate, sharp, prorsiradiate primary ribs, which branch into two or, more rarely, three secondaries at the ventrolateral region and cross the venter with slight forward-directed convexity (Fig.

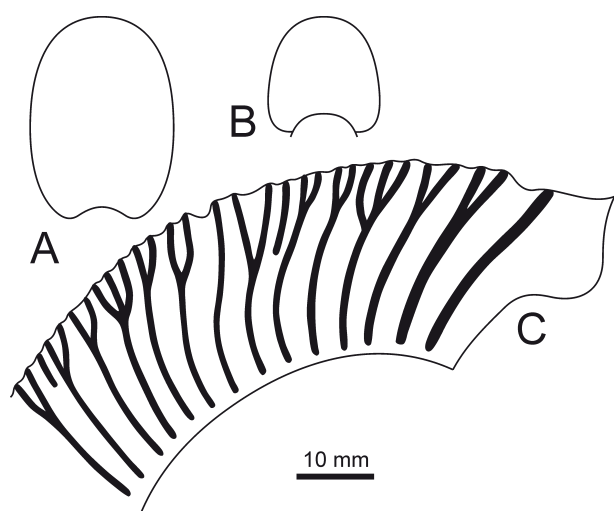


Fig. 50: A. *Perisphinctes* (*Dichotomosphinctes*) cf. *tizianiformis* CHOFFAT, 1893; Dhosa Conglomerate Bed, Jara Dome; GZN2009II 206. Whorl section at unknown diameter. B-C. *Perisphinctes* (*Dichotomosphinctes*) *tizianiformis* CHOFFAT, 1893; Kantkote Ammonite Beds, Trama River. B. Whorl section at ca. 43 mm diameter; GZN2010I 243. C. Ribbing pattern on right flank at ca. 105 mm diameter; GZN2010I 149.

50C). Rarely, isolated secondary ribs occur, giving the appearance of trifurcation or polygyrate ornamentation. Ribs on outer whorl moderately sharp. Constrictions at least three on outer whorl, in addition to a broader constriction just before the aperture. Umbilical wall distinct, smooth, and with undercut.

Remarks: Specimen GZN2010I 149 is a complete microconch with well preserved small lappets. Its ornamentation and proportional dimensions match *Perisphinctes tizianiformis* as described and illustrated by CHOFFAT (1893). This species has been originally described from Middle Oxfordian rocks of Portugal (Plicatilis to Transversarium zones; SIEMIRADZKI, 1898; OPPENHEIMER, 1907; RENZ *et al.*, 1975). Despite this, the name of the species has also been used for Upper Oxfordian to Lower Kimmeridgian forms (SCHAIRER, 1967; SCHLEGELMILCH, 1994), which were assigned to the genus *Orthosphinctes* SCHINDEWOLF. So far, this genus has not been recorded from Middle Oxfordian rocks and although specimen GZN2010I 149 with its small lappets at the aperture resembles other forms of this taxon from younger rocks, it has been retained in *Dichotomosphinctes* for now (R. ENAY, pers. comm., 2012).

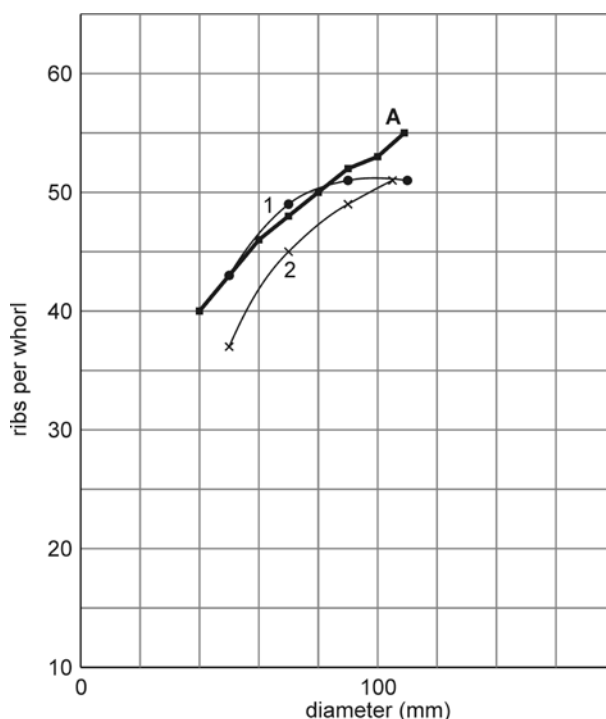


Fig. 51: Rib curve of *Perisphinctes* (*Dichotomosphinctes*) *tizianiformis* CHOFFAT, 1893 from the Kachchh Basin (A: GZN2010I 149) compared to the curve of the holotype (1: constructed from CHOFFAT, 1893, pl. 3, fig. 1a) and *Orthosphinctes* (*Orthosphinctes*) *tiziani* (OPPEL, 1863) (2: constructed from ARKELL, 1935, pl. C, fig. 1a).

Orthosphinctes (*Orthosphinctes*) *tiziani* (OPPEL) as figured by ARKELL (1935, p. xxxiii, pl. C, fig. 1) is also a close match, but is more tightly coiled and comes from the Bimammatum Zone (GYGI, 2003).

***Perisphinctes* (*Dichotomosphinctes*) cf. *tizianiformis*
CHOFFAT, 1893**

Pl. XV, fig. 7; Fig. 50A; Tab. 33

- cf. 1893. *Perisphinctes tizianiformis* CHOFFAT, p. 29, pl. 3, figs. 1-4.
 cf. 1898. *Perisphinctes tizianiformis* CHOFFAT. – SIEMIRADZKI, p. 253.
 cf. 1907. *Perisphinctes tizianiformis* CHOFFAT. – NEUMANN, p. 28.
 cf. 1907. *Perisphinctes tizianiformis* CHOFFAT. – OPPENHEIMER, p. 244.
 cf. 1994. *Orthosphinctes* (*Orthosphinctes*) *tizianiformis* (CHOFFAT). – SCHLEGELMILCH, p. 65, pl. 22, fig. 4.

Material: One specimen from the Dhosa Conglomerate Bed of the Jara Dome (GZN2009II 206).

Remarks: This is a small fragment of a compressed, evolute shell, showing constrictions and ornamentation (including trifurcation) similar to *Perisphinctes* (*Dichotomosphinctes*) *tizianiformis* (CHOFFAT) described above.

***Perisphinctes* (*Dichotomosphinctes*) sp.
Pl. VI, fig. 5; Tab. 34**

Material: Two specimens. One specimen from the Dhosa Oolite of the Jara Dome (GZN2010I 1090). One specimen from the Dhosa Oolite south of Lodai, Habo Dome (GZN2010I 1010).

Description: Shells with parts of the body chamber preserved, evolute, compressed. Whorl section oval with moderately arched flanks merging smoothly into moderately arched venter. Ornamentation consists of gradually varicostate, moderately thick, distantly spaced, prorsiradiate primary ribs indistinctly branching into two to three secondaries at the ventrolateral shoulder. Occasionally, free secondary ribs occur. Secondaries cross the venter with slight forward-directed convexity. Constrictions present.

Remarks: The specimens are poorly preserved. Specimen GZN2010I 1090 is a microconch. This inference is based on the small size of the shell and the closely spaced suture lines at the end of the phragmocone. The outer whorl of specimen GZN2010I 1010 does not show any suture line, but is too poorly preserved to allow further inferences. The ornamentation of the inner whorls is similar to that of *Perisphinctes colei* SPATH (1931a, p. 421, pl. 80, fig. 2a, b) and the specimens described above as *Perisphinctes* (*Arisphinctes*) cf. *colei* most likely represent the dimorphic partner to the present microconchs.

Subgenus *Dichotomoceras* BUCKMAN, 1919

Type species: *Dichotomoceras dichotomum* BUCKMAN, 1920.

Remarks: Small, evolute, compressed to depressed, with sharp, bifurcating ribs. Similar to *Orthosphinctes*, but ribs are sharper, more distant, and there are no constrictions on the outer whorls. ENAY (1966, p. 502) included *Divisosphinctes* BEURLIN (1925, p. 27) in this subgenus. Its type species, *Ammonites bplex bifurcatus* QUENSTEDT, had been included by SPATH (1931a, p. 470) in the synonymy of *Dichotomoceras*.

***Perisphinctes* (*Dichotomoceras*) cf. *virguloides*
WAAGEN, 1875**

Pl. XIV, fig. 1; Fig. 52; Tab. 35

- cf. 1875c. *Perisphinctes virguloides* WAAGEN, p. 203, pl. 49, fig. 1a, b (non pl. 47, fig. 4a, b; compare SPATH, 1931a, p. 451).
 cf. 1931a. *Prososphinctes virguloides* WAAGEN. – SPATH, p. 441, pl. 70, fig. 3, pl. 90, fig. 4.
 cf. 1934. *Prososphinctes virguloides* WAAGEN. – SPATH, p. 12, pl. 1, figs. 3, 4a, b, 6, pl. 2, fig. 3, 4a, b, pl. 4, fig. 5a, b (non pl. 5, fig. 7).
 cf. 1959b. *Prososphinctes virguloides* WAAGEN. – COLLIGNON, pl. 88, fig. 351.

Material: Three specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 099, 108, 130).

Description: Shells moderately large, incomplete, evolute, compressed. Whorl section with flat flanks and moderately rounded venter (Fig. 52A). Ornamentation consists of gradually varicostate, fine (inner whorls) to moderately coarse (outer whorls; Fig. 52B), long, biplicate, slightly prorsiradiate primary ribs, branching into two slightly below the ventrolateral region. The slightly thinner secondaries cross the venter with faint forward-directed convexity. Occasionally, a third single secondary occurs. Constrictions distinct, inclined towards aperture, two per whorl.

Remarks: The specimens are well preserved but fragmentary. The biplicate ribs branching below the ventrolateral region and the compressed whorl section match very well *Perisphinctes virguloides* as described by WAAGEN (1875c). The specimen figured by SPATH (1934) on pl. 5, fig. 7 probably does not belong to this species because of the higher points of bifurcation. Due to the fragmentary nature of the specimens, they have been assigned to this species only tentatively. Additional material of this species from the Gangta Bet, which will be discussed in a separate publication, place the taxon firmly in the subgenus *Dichotomoceras*.

As WAAGEN (1875c, p. 203) already has pointed out, the inner whorls of this species are similar to *Perisphinctes* (*Liosphinctes*) *plicatilis* (J. SOWERBY), but the primary ribs bifurcate slightly lower than in *plicatilis*. The present

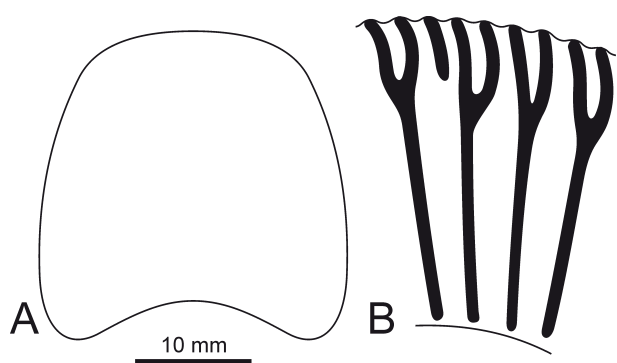


Fig. 52: *Perisphinctes* (*Dichotomoceras*) cf. *virguloides* WAAGEN, 1875; Kantkote Ammonite Beds, Kantkote Village. A. Whorl section at unknown diameter; GZN2010I 130. B. Ribbing pattern on left flank at unknown diameter; GZN2010I 108.

specimens differ from the new species *Perisphinctes* (*Arisphinctes*) *kantkotensis*, described above, from the same horizon in having denser ribbing and coarser secondary ribs.

Earlier records from the Kachchh Basin: WAAGEN (1875c) described the species from the Kantkote Sandstone (Wagad Uplift) and Gangta Bet. SPATH (1931a) mentioned the species from Gangta Bet and with doubts from the Dhosa Oolite of Kachchh Mainland and from sediments north of Wamka (Wagad Uplift).

***Perisphinctes* (*Dichotomoceras*) cf. *besairiei*
(COLLIGNON, 1959)
Pl. XV, figs. 1-3; Tab. 36**

cf. 1959b. *Divisosphinctes besairiei* COLLIGNON, pl. 88, fig. 350.

Material: One specimen from the Patasar Shale member above the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (OUMNH JY.1169).

Description and remarks: This is a distorted fragment of a small, evolute shell with a compressed whorl section. The ornamentation consists of sharp, thin, prorsiradiate primary ribs bifurcating just below the ventrolateral region. Secondaries cross the venter with forward-directed convexity. The outer whorl most likely represents part of the body whorl as no suture line has been observed. Shallow constrictions present. The ornamentation of the shell matches well the species described by COLLIGNON (1959b), but owing to the poor state of preservation, the present specimen has been assigned to the species only tentatively. ENAY (1966) considered *Divisosphinctes* BEURLIN as a junior synonym of *Dichotomoceras*, a view followed in the present study. The species is also similar to *Perisphinctes* (*Dichotomoceras*) *dichotomoides* Arkell and *P. (D.) bifurcatus* (QUENSTEDT) (compare rib curves in ENAY, 1966, textfig. 157).

***Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomoceras*)
bifurcatoides ENAY, 1966
Pl. XV, figs. 8-10; Fig. 53; Tab. 37**

cf. 1966. *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* ENAY, p. 509, pl. 34, figs. 1-4, figs. 155-2, 157.

Material: Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 117, 124).

Description: Shells small, only inner whorls preserved, evolute, compressed. Whorl section with faintly arched flanks and faintly convex venter (Fig. 53A). Ornamentation consists of fine and closely spaced ribs in the nucleus becoming slightly thicker and more distant on outer whorls (Fig. 53B). The sharp, prorsiradiate primary ribs bifurcate slightly below the ventrolateral shoulder, occasionally visible in the umbilicus. Secondaries cross the venter with forward-directed convexity. Primary ribs originate in a rursiradiate fashion near the umbilical suture. Umbilical wall short and distinct. Constrictions present.

Remarks: These fragments of inner whorls have been recorded from the Bifurcatus Zone (top of the Kantkote Ammonite Beds). The whorl section and ornamentation is similar to *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* as described by ENAY (1966). The ornamentation of the specimens is also similar to *Perisphinctes* (*Perisphinctes*) *subwartaeformis* (ARKELL, 1947b, p. 367, pl. 77, fig. 5a, b, textfig. 129), except for the occurrence of constrictions in the present specimens. However, the inner whorls of the specimens from the Amphill Clay of northern England are not well preserved and the nature of the outermost whorls is not known. Constrictions in *bifurcatoides* are absent on the outer whorls but well developed on inner whorls (ENAY, 1966). The ratio between whorl height and thickness in the present specimens is comparable to *Perisphinctes virguloides* WAAGEN (1875c, p. 203, pl. 49, fig. 1a, b; COLLIGNON, 1959b, pl. 88, fig. 351), which also shows constrictions on the inner whorls.

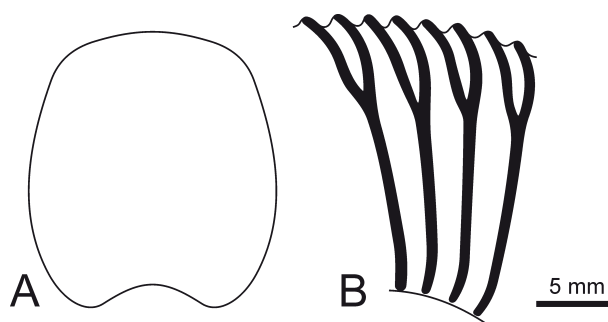


Fig. 53: *Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* ENAY, 1966; Kantkote Ammonite Beds, Kantkote Village; GZN2010I 124. A. Whorl section at unknown diameter. B. Ribbing pattern on left flank at unknown diameter.

Perisphinctes (*Dichotomosphinctes*) *subhelenae* (SPATH, 1931a, p. 437, pl. 87, fig. 10a, b, pl. 101, figs. 2, 3, 10), which occurs in older horizons in the Plicatilis Zone, is a closely related ally, perhaps the ancestor.

***Perisphinctes* (*Dichotomoceras*) cf. *bifurcatus*
(QUENSTEDT, 1847)**

Pl. XVI, figs. 3-5; Fig. 54; Tab. 38

- cf. 1847. *Ammonites biplex bifurcatus* QUENSTEDT, p. 163, pl. 12, fig. 11.
 cf. 1966. *Perisphinctes* (*Dichotomoceras*) *bifurcatus* (QUENSTEDT). – ENAY, p. 504, pl. 33, figs. 1-7, textfigs. 153, 3-7.
 cf. 2000. *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatus* (QUENSTEDT). – GYGI, p. 87, pl. 8, fig. 3.
 cf. 2009b. *Dichotomoceras* gr. *bifurcatus* (QUENSTEDT). – KRISHNA *et al.*, p. 474, pl. 3, figs. 1a, b, 3a, b, 4a, b.

Material: Two specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 118, 123).

Description: Shell small, evolute, depressed. Whorl section slightly subquadrate with arched flanks, which merge smoothly into the well rounded venter (Fig. 54A). Ornamentation consists of sharp primary ribs bifurcating slightly below the ventrolateral region. Occasionally, primaries split just above the umbilical margin (Fig. 54B). Secondaries cross the venter with slight forward-directed convexity. Constrictions moderately distinct.

Remarks: The present specimens represent only inner whorls. The proportional dimensions are comparable to *P. (Dichotomoceras) bifurcatus*. However, in the absence of outer whorls, which are always compressed, the assignment to this species has been made with qualification. The occasional splitting of primaries just above the umbilical margin may be a sign of constrictions, which can also be seen in the specimens figured by ENAY (1966).

Earlier records from the Kachchh Basin: KRISHNA *et al.* (2009b) described the species from the Wagad Uplift, close to Kantkote Village.

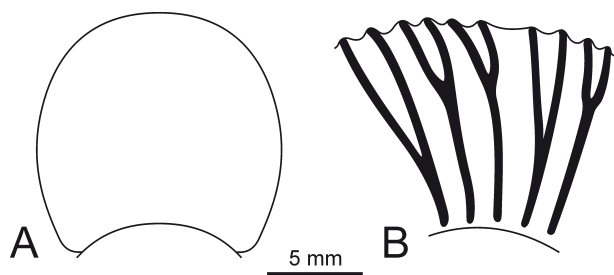


Fig. 54: *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatus* (QUENSTEDT, 1847); Kantkote Ammonite Beds, Kantkote Village; GZN2010I 118. A. Whorl section at ca. 37 mm diameter. B. Ribbing pattern on left flank at ca. 34 mm diameter.

***Perisphinctes* (*Dichotomoceras*) gr. *crassus*
ENAY, 1966**

Pl. XVI, figs. 6-8; Figs. 55, 56; Tab. 39

1966. *Perisphinctes* (*Dichotomoceras*) *crassus* ENAY, p. 507, pl. 33, fig. 8, pl. 34, fig. 5, textfig. 154.
 1979. *Perisphinctes* (*Dichotomoceras*) *crassus* ENAY. – SAPUNOV, p. 86, pl. 20, figs. 6-9.
 1989. *Perisphinctes* (*Dichotomoceras*) *crassus* ENAY. – MELENDEZ, p. 349, pl. 61, figs. 1, 5, 7.
 2001. *Perisphinctes* (*Dichotomoceras*) *crassus* ENAY. – ENAY & GYGI, p. 86, pl. 20, figs. 6-9.
 2009b. *Dichotomoceras crassus* ENAY. – KRISHNA *et al.*, p. 474, pl. 1, fig. 1a, b.

Material: Ten specimens. Seven specimens from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 092, 097, 105, 120-122, 126). Two specimens from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (GZN2010I 139, 141). One stray specimen from the Trama River, Wagad Uplift (GZN2010I 233).

Description: Shells small, incomplete, evolute, depressed. Whorl section subcircular (inner whorls) to suboval (outer whorls) with arched flanks merging into a rounded venter. Greatest width at approximately one-fourth of whorl height (Fig. 55A, B). Ornamentation consists of fine (inner whorls) to moderately coarse (outer whorls), sparse, slightly prorsiradiate primary ribs, which branch into two secondaries slightly below the ventrolateral region (Fig. 55C, D). Secondaries cross the venter with slight forward-directed convexity. Commonly, secondaries of one primary rib are connected with two adjacent primaries on the other side (“galloping”). Ribbing density is moderate, slightly increasing from diameters of 30 to 100 mm (Fig. 56). Constrictions shallow, at least two per whorl. Umbilical wall indistinct.

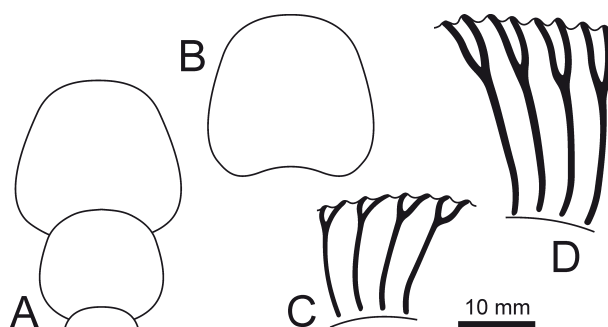


Fig. 55: *Perisphinctes* (*Dichotomoceras*) gr. *crassus* ENAY, 1966; Kantkote Ammonite Beds, Kantkote Village (A, B, D) and Trama River (C). A. Whorl section at unknown diameter; GZN2010I 105. B. Whorl section at unknown diameter; GZN2010I 122. C. Ribbing pattern on right flank at ca. 56 mm diameter; GZN2010I 141. D. Ribbing pattern on left flank at ca. 96 mm diameter; GZN2010I 097.

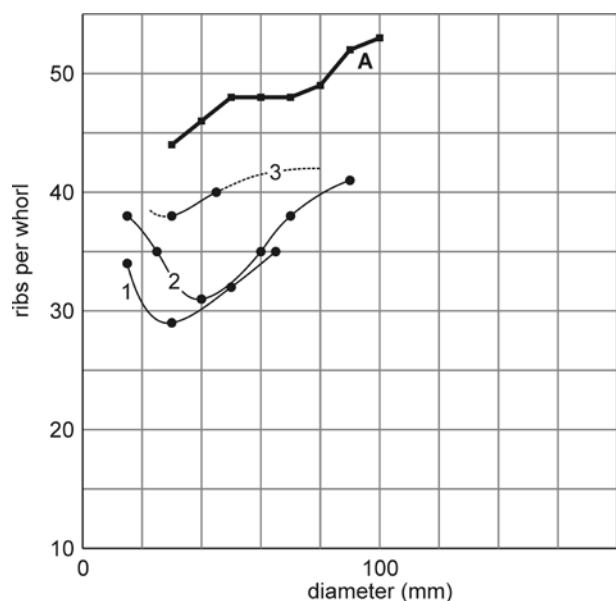


Fig. 56: Rib curve of *Perisphinctes (Dichotomoceras)* gr. *crassus* ENAY, 1966 from the Kachchh Basin (A: GZN2010I 097) compared to previously published curves of this species (1, 3: ENAY, 1966, textfig. 154, no. 1, 2; 2: holotype, ENAY, 1966, textfig. 154).

Remarks: The ribbing pattern matches *Perisphinctes (Dichotomoceras) dichotomus* (BUCKMAN) from the Upper Oxfordian as defined by ARKELL *et al.* (1957, p. L322, fig. 411), but this is a more compressed species (BUCKMAN, 1920, vol. 3, p. 27-28, pl. 139, fig. A; ARKELL, 1947b, p. 358, pl. 75, fig. 1). The present specimens do not differ from specimen GZN2010I 135 described below as *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI in the style of ribbing, but the ribs are slightly more distant and the whorl section is slightly depressed in the present specimens. They also differ from *Perisphinctes (Dichotomoceras) crassus* ENAY (1966, p. 507) in being slightly more compressed. KRISHNA *et al.* (2009b) has not given dimensions, but the density of ribs in the present specimens is similar to that of their specimens described as *Perisphinctes (Dichotomoceras) crassus*. The ribbing density of the present material is slightly higher than seen in rib curves of the species constructed by ENAY (1966; compare Fig. 56). A minimum in rib density around a diameter of 30 to 40 mm seems to be characteristic for the species, but in the present material, it was not possible to count the ribs on the smallest whorls. Due to these differences, the specimens are assigned to the species only tentatively. GZN2010I 139 is a poorly preserved specimen representing only inner whorls. The whorl section and the ornamentation including constrictions are comparable to *P. (Dichotomoceras) crassus*. GZN2010I 105 is a fragmentary specimen, slightly laterally distorted. The fragment represents a small part of the body chamber of

a compressed, moderately large, gradually varicostate *Perisphinctes*.

Earlier records from the Kachchh Basin: KRISHNA *et al.* (2009b) described the species from the *Stenocycloides* Subzone (Bifurcatus Zone, early Late Oxfordian) close to Kantkote Village, Wagad Uplift.

***Perisphinctes (Dichotomoceras)* cf. *dichotomus* (BUCKMAN, 1919)**

Pl. XVI, figs. 1, 2; Fig. 57; Tab. 40

cf. 1919. *Dichotomoceras dichotomum* BUCKMAN, p. 27, pl. 139, figs. A-E.

cf. 1947b. *Perisphinctes (Biplices) dichotomus* (BUCKMAN). – ARKELL, p. 358, pl. 75, fig. 1.

Material: One specimen from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 110).

Description: Small fragment of the body chamber of a moderately large, evolute, and slightly depressed form. Whorl section subquadrangular with slightly arched flanks and rounded venter (Fig. 57A). Ornamentation on body chamber consists of prorsiradiate, thick, sharp, distant, biplicate ribs. Primaries originate from inner part of umbilical margin in a rursiradiate fashion and then turn forward, branching slightly below the ventrolateral region (Fig. 57B). Secondaries cross the venter straight or with very slight forward-directed convexity. Umbilical wall short, smooth, steep.

Remarks: The thickness, density and style of ribbing are very similar to *Perisphinctes (Dichotomoceras) dichotomus* illustrated by ARKELL (1947b). However, the “galloping” visible in the specimens figured by ARKELL (1947b; i.e. secondaries of one primary rib being connected with two adjacent primaries on the other side) cannot be observed in the present specimen. Possibly, this is not a diagnostic feature, but common in perisphinctids.

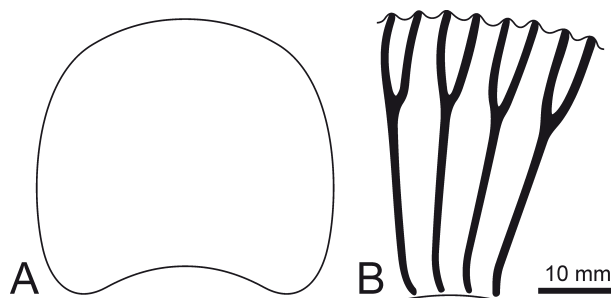


Fig. 57: *Perisphinctes (Dichotomoceras)* cf. *dichotomus* (BUCKMAN, 1920); Kantkote Ammonite Beds, Kantkote Village; GZN2010I 110. A. Whorl section at unknown diameter. B. Ribbing pattern on right flank at unknown diameter.

Perisphinctes (Dichotomoceras) sparsicostatus
(COLLIGNON, 1959)

Pl. XVII, figs. 1-9; Figs. 58, 59; Tab. 41

1959b. *Dichotomoceras sparsicostatum* COLLIGNON, pl. 66, fig. 294.

Material: Twenty-nine specimens. One specimen from the Dhosa Oolite (GZN2009II 080) and eighteen specimens from the Dhosa Conglomerate Bed (GZN2009II 002, 003, 058, 059, 061-065, 073, 192, 199, OUMNH JY.475, JY.482, JY.531, JY.534, JY.536, JY.537) of the Jara Dome. Eight specimens from the Dhosa Conglomerate Bed of the Jumara Dome (GZN2009II 066, GZN2010I 1056, 1058, 1062, 1063, 1065-1067). One specimen from the Dhosa Oolite (GZN2009II 249) and one specimen from the Dhosa Conglomerate Bed (GZN2010I 1003) at Ler, southeast of Bhuj.

Description: Shells small, evolute, incomplete, depressed. Whorl section subquadrangular with distinctly arched flanks and venter (Fig. 58A-E). Ornamentation consists of gradually varicostate, fine to coarse primary ribs, which originate slightly rursiradial at the umbilical margin, turning prorsiradial on the flanks and branch into two secondaries at the ventrolateral shoulder (Fig. 58G, H). Occasionally small tubercles are developed at the points of bifurcation. Secondaries cross the venter with slight forward-directed convexity. Occasionally, a single, undivided primary rib runs without branching along moderately deep constrictions. Ribbing density is low, increasing slightly from diameters of 30 to about 80 mm (Fig. 59). Commonly, secondaries of one primary rib are connected with two adjacent primary ribs on the other side ("galloping").

Remarks: These specimens represent inner whorls of phragmocones matching *Dichotomoceras sparsicostatum* as described by COLLIGNON (1959b). Similar taxa include *Perisphinctes (Arisphinctes) rota* WAAGEN and *Perisphinctes (Kranaosphinctes) nerunaensis* (SPATH) described above, but both have larger shell diameter and a higher whorl height to thickness ratio.

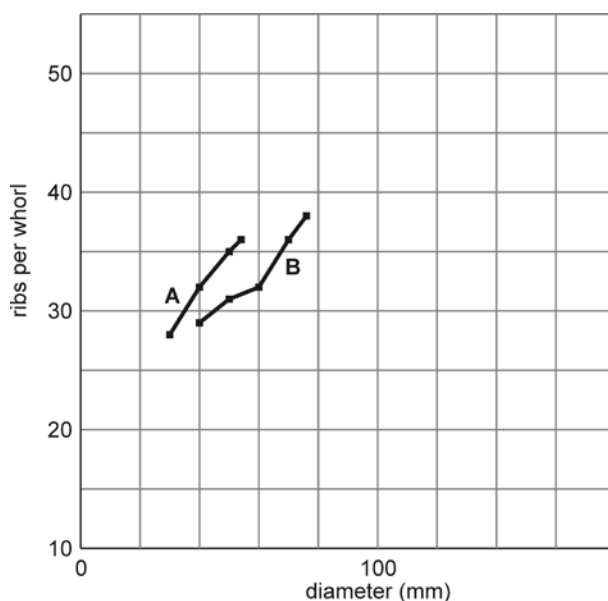


Fig. 59: Rib curves of specimens of *Perisphinctes (Dichotomoceras) sparsicostatus* (COLLIGNON, 1959) from the Kachchh Basin (A: GZN2009II 003; B: GZN2010I 1062).

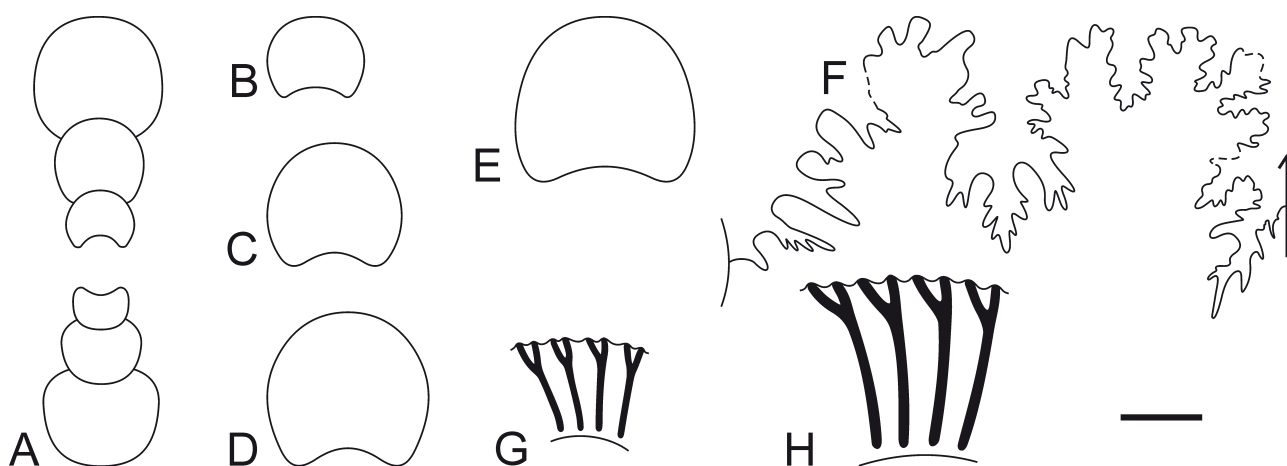


Fig. 58: *Perisphinctes (Dichotomoceras) sparsicostatus* (COLLIGNON, 1959). Dhosa Conglomerate Bed, Jara Dome (A, B, F-H) and Jumara Dome (C, D), Dhosa Oolite, Jara Dome (E). A. Cross section (scale bar = 10 mm); GZN2009II 199. B. Whorl section at ca. 35 mm diameter (scale bar = 10 mm); GZN2009II 002. C. Whorl section at unknown diameter (scale bar = 10 mm); GZN2010I 1066. D. Whorl section at unknown diameter (scale bar = 10 mm); GZN2010I 1067. E. Whorl section at unknown diameter (scale bar = 10 mm); GZN2009II 080. F. Suture line at ca. 79 mm diameter (scale bar = 4 mm); GZN2009II 073. G. Ribbing pattern on left flank at ca. 41 mm diameter (scale bar = 10 mm); GZN2009II 059. H. Ribbing pattern on left flank at unknown diameter (scale bar = 10 mm); GZN2009II 073.

Perisphinctes (Dichotomoceras) stenocycloides

SIEMIRADZKI, 1898

Pl. XVIII, figs. 1-5; Figs. 60, 61; Tab. 42

1898. *Perisphinctes stenocycloides* SIEMIRADZKI, p. 254, pl. 20, fig. 11.
 1959b. *Dichotomosphinctes stenocycloides* SIEMIRADZKI. – COLLIGNON, pl. 65, fig. 291.
 1988. *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI. – ENAY *et al.*, pl. 1, fig. 3, pl. 3, fig. 2.
 1989. *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI. – MELENDEZ, p. 311, pl. 51, figs. 1-5.
 2000. *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI. – GYGI, p. 85, pl. 9, fig. 3.
 2009b. *Dichotomoceras* gr. *stenocycloides* (SIEMIRADZKI). – KRISHNA *et al.*, p. 474, pl. 2, fig. 4a, b, pl. 3, figs. 2a, b, 5a, b.

Material: Five specimens. One specimen from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (GZN2010I 102). Four specimens from the Kantkote Ammonite Beds in the Tramu River, Wagad Uplift (GZN2010I 135, 140, 182, 258).

Description: Shells moderately large, evolute, compressed. Whorl section suboval with slightly arched flanks merging smoothly into well rounded venter (Fig. 60A-C). Umbilical wall short but distinct, merging with flank at the rounded umbilical margin. Ornamentation consists of prorsiradial, gradually varicostate, fine to moderately coarse primary ribs originating at the umbilical suture, branching into two secondaries slightly below the ventrolateral region (Fig. 60D, E). Secondaries cross the venter with slight forward-directed convexity. The anterior secondaries show a slightly stronger forward inclination than primaries. Occasionally, secondaries of one primary rib are connected with two adjacent primaries on the other side (“galloping”). Ribbing density is moderate, increasing considerably from diameters of 60 to 120 mm (Fig. 61).

Remarks: The largest specimen (GZN2010I 258) is just broken at the aperture, therefore the nature of the peristome cannot be observed. The style of ornamentation, the rib curve (Fig. 61), and the proportional dimensions of the specimens are similar to *P. (Dichotomoceras) stenocycloides* as recorded by GYGI (2000) and KRISHNA *et al.* (2009b). The style of ornamentation is also very similar to *Perisphinctes (Dichotomosphinctes) luciae* DE

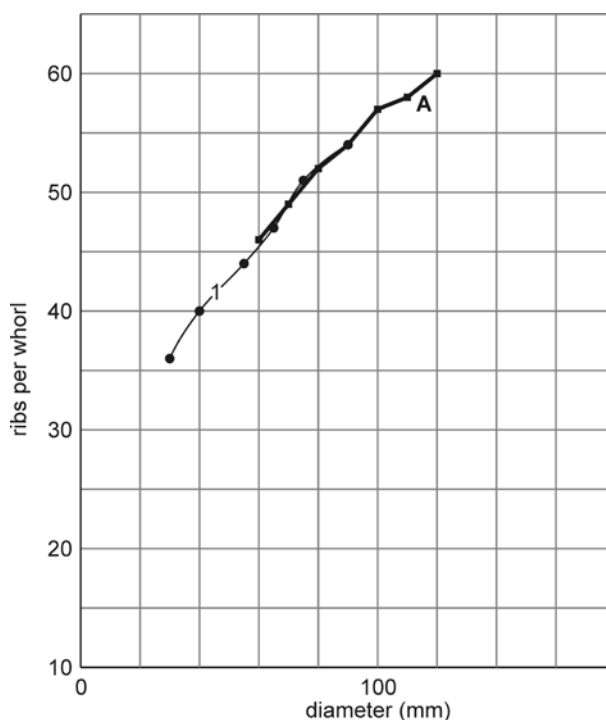


Fig. 61: Rib curve of *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI, 1898 from the Kachchh Basin (A: GZN2010I 258) compared to the curve of a slightly distorted specimen from Europe (1: constructed from GYGI, 2000, pl. 9, fig. 3).

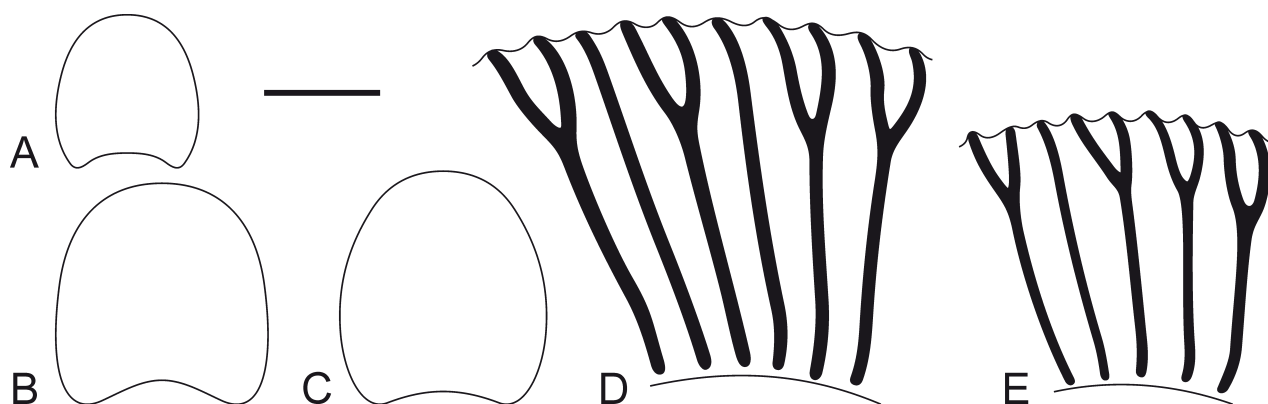


Fig. 60: *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI, 1898; Kantkote Ammonite Beds, Kantkote Village (A, E) and Tramu River (B-D). A. Whorl section at unknown diameter (scale bar = 15 mm); GZN2010I 102. B. Whorl section at ca. 102 mm diameter (scale bar = 15 mm); GZN2010I 140. C. Whorl section at ca. 105 mm diameter (scale bar = 15 mm); GZN2010I 135. D. Ribbing pattern on left flank at ca. 118 mm diameter (scale bar = 10 mm); GZN2010I 258. E. Ribbing pattern on left flank at unknown diameter (scale bar = 10 mm); GZN2010I 102.

RIAZ from the Middle Oxfordian (Transversarium Zone) of the Paris Basin as illustrated by ENAY & BOULLIER (1981, pl. 2, fig. 4; compare also SPATH, 1931a, p. 439, pl. 72, fig. 6a, b, pl. 77, fig. 2; ENAY, 1966, p. 494). However, *luciae* shows less evolute coiling. The number of ribs on the outer whorls is also slightly greater in *luciae*.

The proportional dimensions and ornamentation of *stenocycloides* are also similar to *Perisphinctes* (*Dichtomosphinctes*) *auriculatus* ARKELL (1935, pl. B, fig. 3a, b; 1938, p. 77, pl. 14, fig. 5, pl. 17, figs. 4, 7, 8), but since the present specimens lack deep constrictions they can be easily differentiated. *Perisphinctes virguloides* WAAGEN (1875c, p. 203, pl. 49, fig. 1a, b; non pl. 47, fig. 4a, b) shows similar ornamentation but is less evolute.

One additional specimen from the Kantkote Ammonite Beds southwest of the Kantkote Village (GZN2010I 116) exhibits the characteristic features of *P. (D.) stenocycloides*, but since it represents only a small fragment of the shell, it has been identified only as *Perisphinctes* (*Dichotomoceras*) cf. *stenocycloides* (see Tab. 43, Figs. 65, 66).

Earlier records from the Kachchh Basin: KRISHNA *et al.* (2009b) described the species from the Wagad Uplift, close to Kantkote Village.

IV. TAXONOMIC REMARKS

Members of the genus *Perisphinctes* WAAGEN, 1869 described in this publication are closely related and of overall similar morphology. Occasionally only inner whorls were available, which might look almost identical in different species. In these cases, care has been taken to differentiate taxa on the basis of ontogenic changes in style of ornamentation (e.g., thickness, density, orientation, point of branching of ribs, number of secondary ribs, occurrence of free primary or secondary ribs), whorl section (region of maximum thickness, distinct or indistinct umbilical margin and ventrolateral shoulder, shape of lateral and ventral surfaces), proportional dimensions, occurrence of constrictions (number, shape, obliquity), and lastly size.

In the following, taxa which are very closely related and difficult to distinguish will be discussed to highlight their differences and enable reliable identifications.

1. *Perisphinctes subevolutus* - *pagri*

Special attention should be paid to differentiate *Perisphinctes* (*Kranaosphinctes*) *subevolutus* WAAGEN, 1875 and *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875. These species have comparatively small, evolute, and depressed shells with subcircular whorl sections and varicostate ornamentation. The collected specimens are mostly incomplete. Several features help to distinguish the two species. Plotting whorl height versus whorl width (Fig. 62), it becomes obvious that *pagri* is

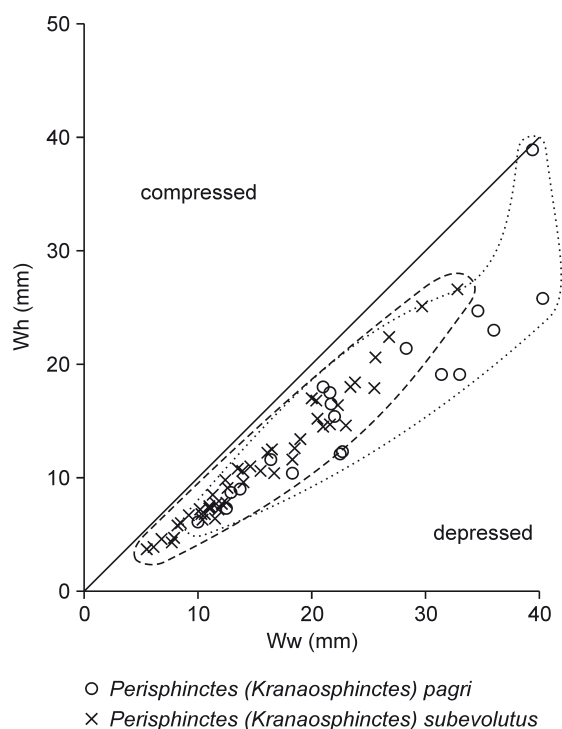


Fig. 62: Whorl height (Wh) versus whorl width (Ww) of specimens of *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875 and *Perisphinctes* (*Kranaosphinctes*) *subevolutus* WAAGEN, 1875.

generally more depressed, although in the outermost whorls whorl height is almost equal to width. While the ratio of the inner whorls can be quite variable and the values of both species overlap, outer whorls can be confidently separated via these dimensions. Additionally, the rib curves of both species are very different. While the number of ribs per whorl in *subevolutus* is rising from 41 at a diameter of 30 mm to 58 at a diameter of 70 mm, it stays almost constant around 40 in *pagri* (Fig. 12). Furthermore, the latter has a smaller umbilicus and commonly trifurcating primary ribs.

Both species occur at different stratigraphic levels. *Subevolutus* is a long-ranging taxon, occurring in beds directly underneath the Dhosa Conglomerate Bed where it has been sampled together with members of the genus *Peltoceratoides* SPATH, 1924 indicating a late Early Oxfordian age (Cordatum Zone; ALBERTI *et al.*, 2011) up to the central part of the Kantkote Ammonite Beds which represents parts of the Middle Oxfordian Plicatilis and Transversarium zones. *Pagri* is stratigraphically more restricted and occurs only in the upper part of the Kantkote Ammonite Beds of early Late Oxfordian age (lower Bifurcatus Zone; see Fig. 66). Due to their similar morphology and successive occurrence we assume that both taxa belong to the same lineage (as already proposed by SPATH, 1931a).

2. *Perisphinctes indogermanus* – *nerunaensis* – *colei* – *rota* – *jacki* – *obliqueplicatus*

Members of this group occur in the Early to Middle Oxfordian rocks of the Dhosa Oolite member of the Kachchh Mainland, except for *Perisphinctes* (*Perisphinctes*) *indogermanus* WAAGEN, 1875 which has been collected from the Kantkote Ammonite Beds of the Wagad Uplift, as well as from the southernmost tip of Khadir Island. Broadly, the taxa can be separated into depressed (*indogermanus*, *nerunaensis*) and compressed (*colei*, *jacki*, *obliqueplicatus*, *rota*) forms. The depressed taxa differ from each other by their whorl section and depth of constrictions, while the compressed ones can be distinguished on the basis of the changes of their whorl height to thickness ratio during shell growth, their whorl sections and ornamentation. In the following their characteristic features are listed:

- A. *Perisphinctes* (*Perisphinctes*) *indogermanus* WAAGEN, 1875: depressed, whorl section subrounded; ornamentation: ribs with slight forward-directed concavity, bifurcating slightly below the ventrolateral region; rarely three secondary ribs, occasionally the third one free; constrictions shallow, slightly inclined.
- B. *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* (SPATH, 1931): inner whorls depressed, outer whorls less depressed, whorl section subquadrangular; ornamentation: very gradually varicostate, relatively coarse, and moderately spaced primaries branch at the ventrolateral shoulder into finer secondaries; venter smooth on outer whorl, constrictions deep, slightly inclined, numbering two per whorl.
- C. *Perisphinctes* (*Arisphinctes*) cf. *colei* SPATH, 1931: innermost whorls slightly depressed, outer ones compressed, whorl section subtrigonal to oval; ornamentation: gradually varicostate, primaries with slight forward-directed concavity, branching into two or three finer secondaries at the ventrolateral shoulder, primaries becoming thicker; constrictions distinct, slightly oblique, numbering three per whorl.
- D. *Perisphinctes* (*Arisphinctes*) *rota* WAAGEN, 1875: slightly compressed, whorl section suboval to subquadrate, ornamentation: gradually varicostate primary ribs branch just below the ventro-lateral shoulder into two secondaries, constrictions distinct, numbering three per whorl.
- E. *Perisphinctes* (*Dichotomosphinctes*) *jacki* (SPATH, 1931): innermost whorls depressed, outer whorls compressed, whorl section subquadrangular to oval; ornamentation: isocostate primary ribs, branching regularly into two slightly finer secondaries at the ventrolateral region, primaries occasionally undivided leading to “galloping” of secondaries, constrictions distinct, numbering two to three per whorl.
- F. *Perisphinctes* (*Dichotomosphinctes*) cf. *obliqueplicatus* WAAGEN, 1875: compressed suboval; ornamentation: gradually varicostate, consistently forwardly inclined primary ribs, branching regularly into two finer

secondaries below the ventro-lateral region; constrictions distinct, numbering two per whorl.

3. *Perisphinctes martelli* – *chloroolithicus* – *cotovuiformis* – *plicatilis* – *subhelenae*

These species have been mainly collected from the Kantkote Ammonite Beds southwest of Kantkote Village and in the Trama River of the Wagad Uplift. As they are mostly represented by inner whorls, a differentiation of these taxa can be difficult. Whorl sections and change of ornamentation from inner to outer whorls in the present specimens as well as descriptions and illustrations by previous authors (e.g., WAAGEN, 1875c; ARKELL, 1938, 1939; ENAY, 1966; KRISHNA *et al.*, 1998) have proven useful.

WAAGEN (1875c) stated that “it is not difficult to distinguish *Per. martelli* from the allied species. It has got finer and more numerous ribs and thicker whorls than *Per. plicatilis*, and less fine and also thicker whorls than *Per. chloroolithicus*”. However, the specimens described and figured by WAAGEN (1875c) have consequently been put into synonymy with other species (see taxonomy above). The present material also does not support the statement of WAAGEN (1875c). The inner whorls of specimens assigned here to *P. (Perisphinctes) martelli* have slightly coarser ribs than *chloroolithicus* and a greater whorl width even at greater diameter. *P. (Arisphinctes) chloroolithicus* has finer ribs even at a smaller diameter. However, the actual number of ribs in both species does not differ greatly. *P. (Liosphinctes) plicatilis* is characterized by coarser and more numerous ribs than *chloroolithicus*. Additionally, it is more compressed than *chloroolithicus*.

ARKELL (1938, 1939) illustrated inner and outer whorls of *P. plicatilis* (ARKELL, 1939, p. 145, pl. 29, figs. 1-8) and *P. chloroolithicus* (ARKELL, 1938, p. 95, pl. 18, figs. 1-7). In these figures, there seems to be no difference in the style of ribbing of inner whorls, but *P. plicatilis* is slightly less evolute and has a higher number of ribs, comparable to the present material.

The whorls of *P. martelli* are more depressed, and while the number of ribs might be similar on inner whorls, the ribs are much more distant on outer whorls (ENAY, 1966, p. 373). *P. cf. chloroolithicus* as described by ENAY (1966, p. 364) is compressed until a diameter of 290 mm, but the number of ribs is lower than in *plicatilis*.

Based on the work of the previous authors and the material presented here, the following characteristic features are listed to enable reliable identification of the internal whorls of these closely related taxa:

- A. *Perisphinctes* (*Perisphinctes*) *martelli* (OPPEL, 1863): depressed, inner whorls with convex sides, ornamented with suddenly variocostate, relatively coarse and distant ribs on the inner whorls to folds on outer whorls.
- B. *Perisphinctes* (*Arisphinctes*) *chloroolithicus* (GÜMBEL, 1865): compressed until a diameter of around

290 mm, with sides of inner whorls less convex than in *martelli*, ornamented with moderately coarse ribs on the inner whorls, which become coarser on outer whorls as in *martelli*, but the folds are more distant and less regular (number of ribs is lower than in *plicatilis*).

- C. *Perisphinctes* (*Arisphinctes*) cf. *cotovuiformis* ENAY, 2009: compressed inner whorls and increasingly depressed outer whorls, ornamented with variocostate, moderately coarse ribs on inner whorls and broader folds on outer whorls, primary ribs long, slightly concave towards the front, branching into three finer secondaries, which diminish on body chamber.
- D. *Perisphinctes* (*Liosphinctes*) *plicatilis* (J. SOWERBY, 1817): inner whorls depressed, outer whorls compressed, ribs gradually varicostate, dichotome, very fine to fine, dense, branching at ventrolateral shoulder on inner whorls and slightly above or around mid-lateral height on outer whorls, flanks flat to slightly arched (number of ribs per whorls greater than in *martelli* and *chloroolithicus*).
- E. *Perisphinctes* (*Dichotomosphinctes*) *subhelenae* (SPATH, 1931): compressed with flat flanks, ornamented with rather isocostate, moderately coarse ribs.

V. BIOSTRATIGRAPHY

The first biostratigraphic interpretations of the Oxfordian rocks of the Kachchh Basin using ammonites were made by WAAGEN (1875c, p. 230) and SPATH (1927-1933). However, at that early stage the condensed nature of the Dhosa Oolite member with abundant, though reworked ammonites was not fully understood. No precise correlation with the predominantly siliciclastic succession of the Wagad Uplift was possible. WAAGEN (1875c) recognised Cordatum and Transversarium zones of Europe, although he noted the striking scarcity of European species (see also KRISHNA *et al.*, 2000, p. 324). Interestingly, SPATH (1933, p. 873) recognized five divisions in the Oxfordian succession of the Kachchh Basin and correlated them with four European ammonite zones: Cordatum Zone (Dhosa Oolite Shale, Dhosa Oolite, southern Kachchh); Perarmatum Zone (Lower Dhosa Oolite, northwestern Kachchh); Transversarium Zone (Upper Dhosa Oolite, northwestern Kachchh and Kantkote Sandstone, eastern Kachchh), and Bimammatum Zone (Kantkote Sandstone, eastern Kachchh).

The mixing of ammonites from different zones in the Dhosa Conglomerate Bed was realized already by AGRAWAL (1956), SINGH (1961, p. 231), and AGRAWAL & KACHHARA (1979, p. 142). This amalgamation has been confirmed by later workers (e.g., SINGH, 1989; FÜRSICH *et al.*, 1992; KRISHNA *et al.*, 1996b), but not to the extent as proposed by AGRAWAL & KACHHARA (1979) who considered the entire Dhosa Oolite member

to contain Callovian and Oxfordian ammonites. Most likely, this assumption was a result of wrong identification of ammonites in the field combined with imprecise stratigraphic collecting of specimens. In this context, it is also very important to define the term Dhosa Oolite member, which some workers restricted to the conglomeratic unit at the top (i.e. the Dhosa Conglomerate Bed), while the majority (including the present authors) incorporated also the undisturbed, oolitic sandstone beds below (compare ALBERTI *et al.*, 2012). While the lower beds of the Dhosa Sandstone and Dhosa Oolite might show signs of low sedimentation rates, only the Dhosa Conglomerate Bed contains reworked ammonites.

Most recently KRISHNA *et al.* (e.g., 1996b, 1998, 2009a, b, c) added many more taxa to the list of Oxfordian ammonites of the Kachchh Basin, incorporating also collections from the expanded succession of the Wagad Uplift, thereby refining the old ammonite biozonations proposed by WAAGEN (1873-1875) and SPATH (1927-1933).

Forty-three taxa of the genus *Perisphinctes* WAAGEN, 1869 have been described and illustrated above to provide a comprehensive overview of the taxonomy of the group as well as to further refine the Oxfordian biostratigraphy of the Kachchh Basin. Figures 63-65 illustrate the occurrence of the taxa recorded in the present publication at all sampled sections throughout the Kachchh Basin. On the basis of the temporal distribution of these perisphinctids and the co-occurrence of various ammonites at the different horizons, as well as based on the affinities to other fossils of the Indo-Madagascan and Submediterranean faunal provinces, the following nine *Perisphinctes* levels have been recognized (see Fig. 66).

(1) Dhosa Oolite > 20 cm below the Dhosa Conglomerate Bed (Cordatum Zone)

These beds have yielded several autochthonous specimens of *Peltoceratoides* SPATH, 1924 clearly indicating an Early Oxfordian age (Cordatum Zone; see ALBERTI *et al.*, 2011). Additionally, the following eight taxa of the genus *Perisphinctes* have been collected from this unit: *Perisphinctes* (*Kranaosphinctes*) *subevolutus*, *P.* (*Arisphinctes*) cf. *colei*, *P.* (*A.*) *kheraensis*, *P.* (*A.*) *polymorphus*, *P.* (*A.*) cf. *trifidus*, *P.* (*Dichotomosphinctes*) *jacki*, *P.* (*D.*) *rotiformis*, and *P.* (*D.*) sp.

P. (*K.*) *subevolutus*, *P.* (*D.*) *jacki*, and *P.* (*D.*) sp. occur also autochthonous in higher horizons, while the rest only occasionally occurs reworked in levels (3) to (5). *P.* (*D.*) sp. is the only taxon of the eight which has not been recorded as reworked in the Dhosa Conglomerate Bed, but its proposed dimorphic partner, identified as *P.* (*A.*) cf. *colei* does, therefore it seems reliable to expect this taxon to appear throughout levels (1) to (4). *P.* (*K.*) *subevolutus* is a long-ranging species occurring from the Early Oxfordian Cordatum Zone until the Middle Oxfordian Transversarium Zone (Level 7).

Specimens identified as *P.* (*A.*) cf. *trifidus* show a close

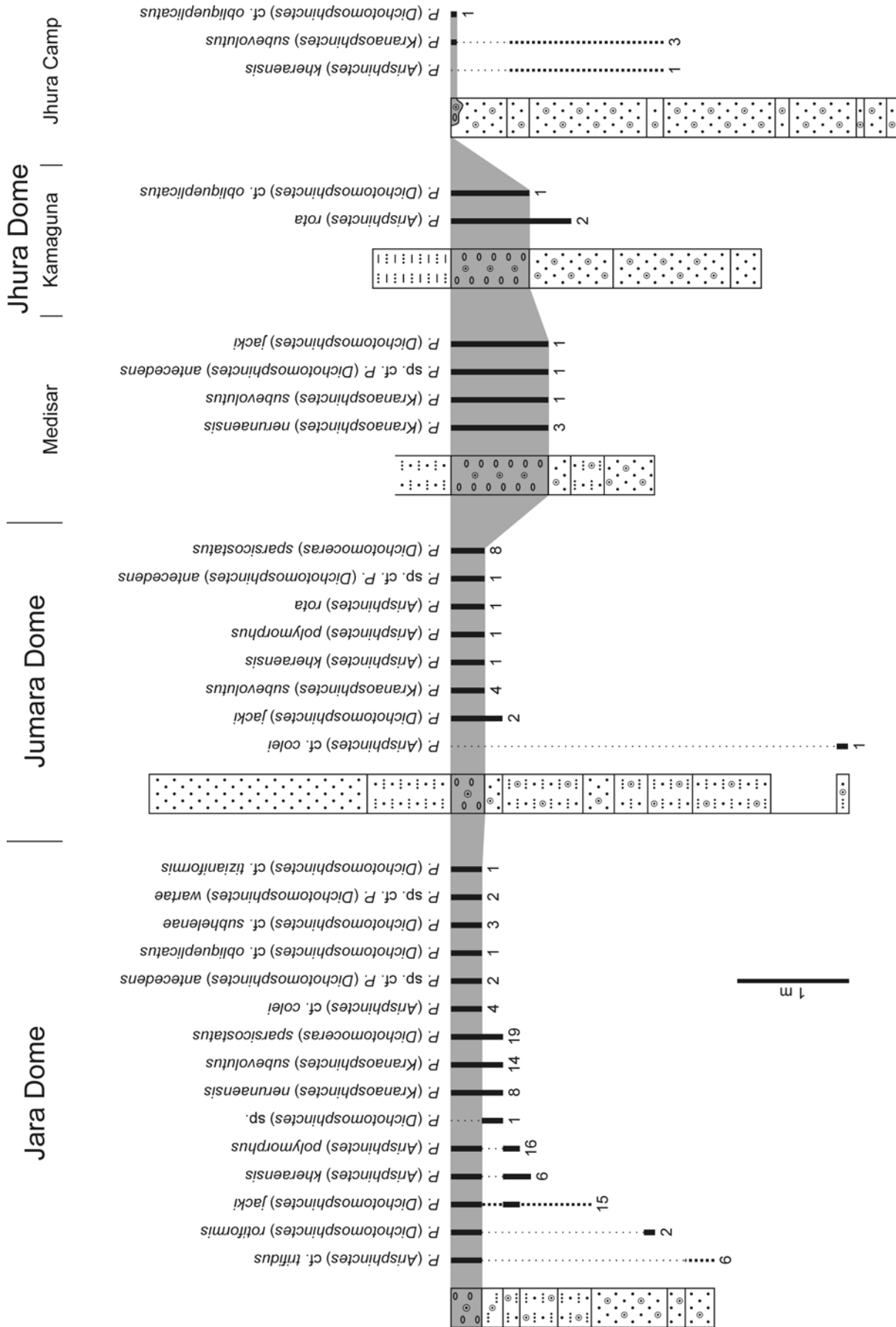


Fig. 63: Schematic lithology of localities on western Kachchh Mainland yielding specimens of the genus *Perisphinctes* WAAGEN, 1869 with the stratigraphic range of the taxa. Numbers below stratigraphic ranges indicate the number of specimens collected from the interval (for legend see Fig. 64).

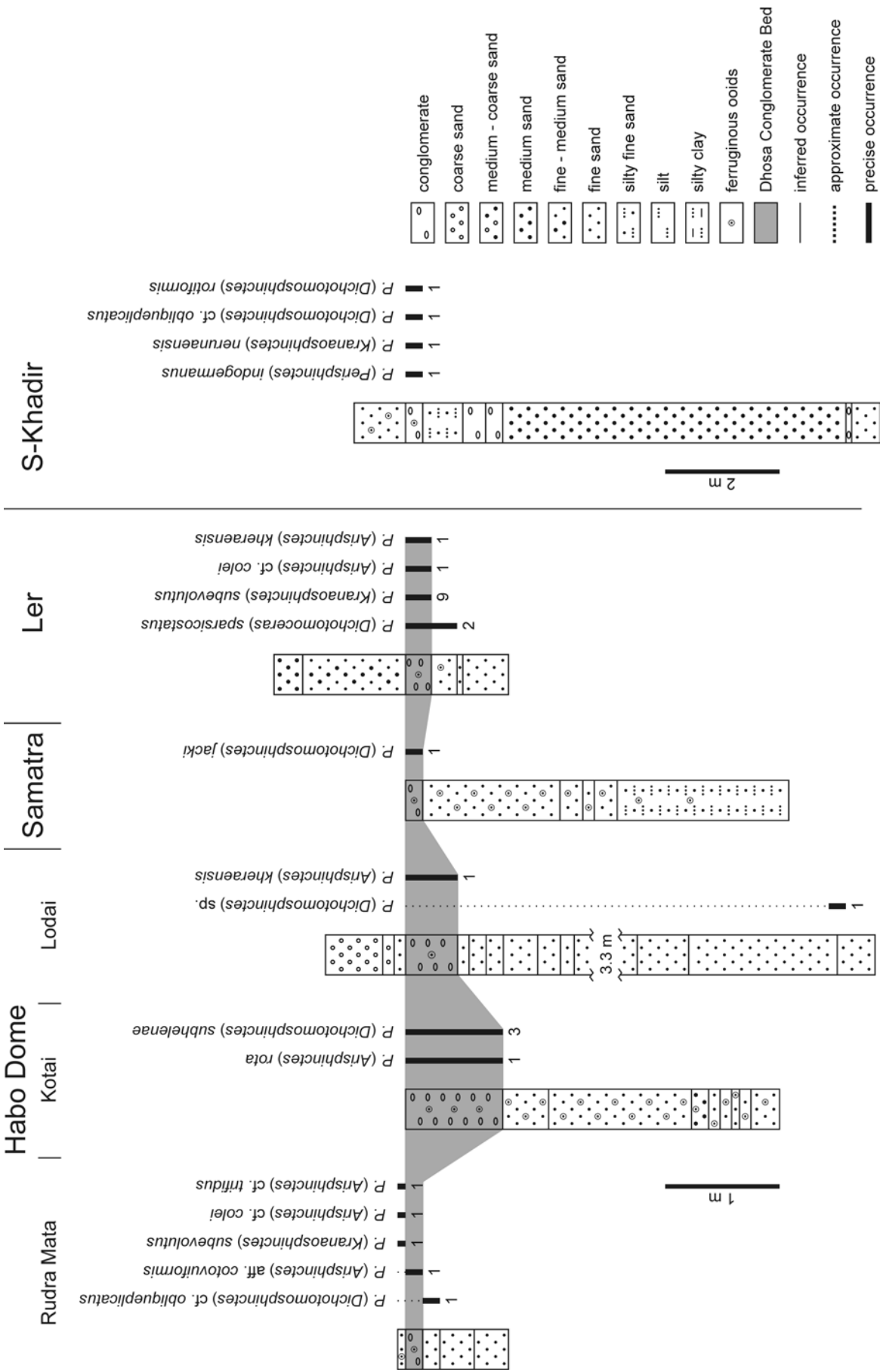


Fig. 64: Schematic lithologies of localities on eastern Kachchh Mainland and southernmost Khadir Island yielding specimens of the genus *Perisphinctes* WAAGEN, 1869 with the stratigraphic range of the taxa. Numbers below stratigraphic ranges indicate the number of specimens collected from the interval.

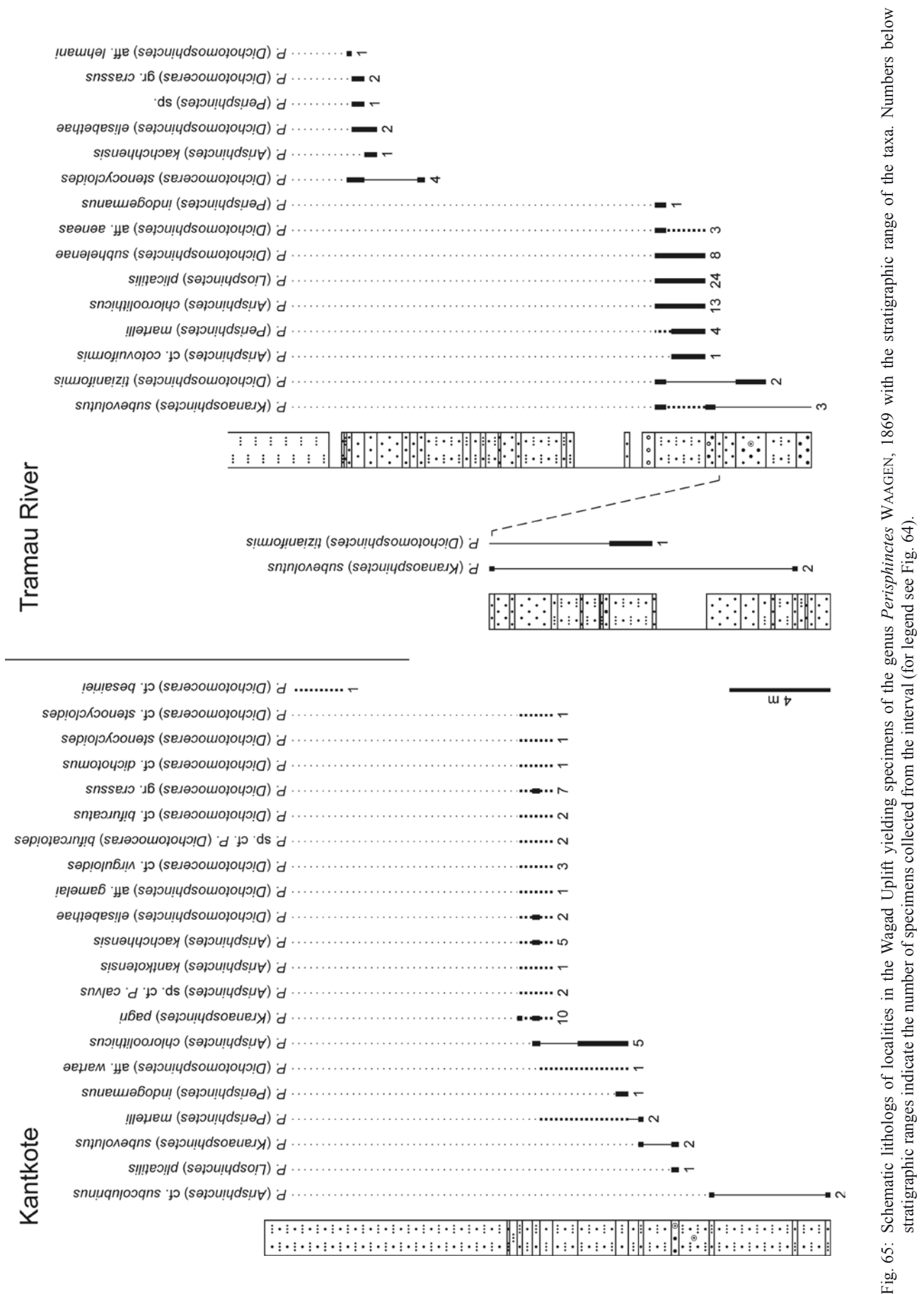


Fig. 65: Schematic lithologs of localities in the Wagad Uplift yielding specimens of the genus *Perisphinctes* WAAGEN, 1869 with the stratigraphic range of the taxa. Numbers below stratigraphic ranges indicate the number of specimens collected from the interval (for legend see Fig. 64).

1. Cordatum Zone (Dhosa Oolite > 20 cm below DCB)	2. Cordatum / Early Plicatilis zones (Dhosa Oolite directly below DCB)	3. Cordatum / Early Plicatilis zones (concretionary slabs in DCB)	reworked		Pli. - Transv.		Bifurcatus		ammonite levels	collected ammonite taxa
			4. Cordatum - Transversarium zones (reworked in matrix of DCB)	5. Cordatum - Transversarium zones (southernmost Khadir Island)	6. Early Plicatilis Subzone (lower part of KAB)	7. Plicatilis - Parandieri subzones (central part of KAB)	8. Stenocycloides Subzone (top part of KAB)	9. ?Grossouvrei Subzone (Patasar Shale mb)		
										<i>P. (Dichotomoceras) cf. besairiei</i>
										<i>P. (Perisphinctes) sp.</i>
										<i>P. (Kraeosphinctes) pagri</i>
										<i>P. (Arisphinctes) sp. cf. P. calvus</i>
										<i>P. (Arisphinctes) kantkotensis</i>
										<i>P. (Arisphinctes) kachchhensis</i>
										<i>P. (Dichotomosphinctes) elisabethae</i>
										<i>P. (Dichotomosphinctes) aff. gamelai</i>
										<i>P. (Dichotomosphinctes) aff. lehmani</i>
										<i>P. (Dichotomoceras) cf. virguloides</i>
										<i>P. sp. cf. P. (Dichotomoceras) bifurcatoides</i>
										<i>P. (Dichotomoceras) cf. bifurcatus</i>
										<i>P. (Dichotomoceras) gr. crassus</i>
										<i>P. (Dichotomoceras) cf. dichotomus</i>
										<i>P. (Dichotomoceras) stenocycloides</i>
										<i>P. (Dichotomoceras) cf. stenocycloides</i>
										<i>P. (Arisphinctes) chloroolithicus</i>
										<i>P. (Perisphinctes) martelli</i>
										<i>P. (Arisphinctes) cf. cotovuiformis</i>
										<i>P. (Liosphinctes) plicatilis</i>
										<i>P. (Dichotomosphinctes) aff. wartae</i>
										<i>P. (Dichotomosphinctes) aff. aeneas</i>
										<i>P. (Perisphinctes) indogermanus</i>
										<i>P. (Dichotomosphinctes) subhelenae</i>
										<i>P. (Dichotomosphinctes) tizianiformis</i>
										<i>P. (Arisphinctes) cf. subcolubrinus</i>
										<i>P. (Arisphinctes) aff. cotovuiformis</i>
										<i>P. sp. cf. P. (Dichotomosphinctes) antecedens</i>
										<i>P. (Dichotomosphinctes) cf. subhelenae</i>
										<i>P. sp. cf. P. (Dichotomosphinctes) wartae</i>
										<i>P. (Dichotomosphinctes) cf. tizianiformis</i>
										<i>P. (Dichotomosphinctes) cf. obliqueplicatus</i>
										<i>P. (Kraeosphinctes) nerunaensis</i>
										<i>P. (Arisphinctes) rota</i>
										<i>P. (Dichotomoceras) sparsicostatus</i>
										<i>P. (Kraeosphinctes) subevolatus</i>
										<i>P. (Dichotomosphinctes) jacki</i>
										<i>P. (Dichotomosphinctes) sp.</i>
										<i>P. (Dichotomosphinctes) rotiformis</i>
										<i>P. (Arisphinctes) polymorphus</i>
										<i>P. (Arisphinctes) cf. colei</i>
										<i>P. (Arisphinctes) kheraensis</i>
										<i>P. (Arisphinctes) cf. trifidus</i>

Fig. 66: Stratigraphic occurrence of taxa of the genus *Perisphinctes* WAAGEN, 1869 collected from the Oxfordian succession of the Kachchh Basin. Levels with predominantly reworked ammonites are shaded in grey (DCB – Dhosa Conglomerate Bed; KAB – Kantkote Ammonite Beds; Pli. – Plicatilis Zone; Transv. – Transversarium Zone; Bif. – Bifurcatus Zone).

resemblance to specimens described as *Perisphinctes helenae* from the Plicatilis or Transversarium Zone by SPATH (1933), ARKELL (1939), ENAY (1966), GYGI (2000, 2001), and CARACUEL *et al.* (2006), as well as from the *Dichotomosphinctes wartae-Proscaphites anar* Zone of Madagascar by COLLIGNON (1959b). However, only a single poorly preserved specimen (OUMNH JY.269) has been found in this interval at the Jara Dome below a horizon with abundant specimens of *Peltoceratoides* (ALBERTI *et al.*, 2011). Thus at this stage it is doubtful whether this species is really long ranging or not.

(2) Dhosa Oolite directly below the Dhosa Conglomerate Bed (Cordatum / Early Plicatilis zones)

The horizon directly underneath the Dhosa Conglomerate Bed is highly fossiliferous and still contains abundant, autochthonous specimens of *Peltoceratoides* from the Early Oxfordian Cordatum Zone (ALBERTI *et al.*, 2011). The present study adds seven taxa of the genus *Perisphinctes* occurring in this bed. *P. (K.) subevolatus*, *P. (Dichotomosphinctes) jacki*, and *P. (D.)* sp. extend into this horizon from Level 1, while *P. (Kranaosphinctes) nerunaensis*, *P. (Arisphinctes) rota*, *P. (Dichotomosphinctes) cf. obliqueplicatus*, and *P. (Dichotomoceras) sparsicostatus* appear for the first time. Most of the taxa recorded from this horizon occur again in one of the reworked levels 4 and 5. Only *P. (Dichotomosphinctes)* sp. has not been found again, but as mentioned above, specimens described as its dimorphic partner, *P. (Arisphinctes) cf. colei*, do occur in concretionary slabs as well as reworked in the matrix of the Dhosa Conglomerate Bed.

P. (K.) nerunaensis, *P. (A.) rota*, and *P. (D.) sparsicostatus* have been recorded from the *Dichotomosphinctes wartae-Proscaphites anar* Zone of Madagascar, while *P. (K.) subevolatus* is also known from the Rauracian (COLLIGNON, 1959b). Why SPATH (1933, p. 872) equated the Rauracian with the Bimammatum Zone of OPPEL, without any record of true index fossils, is unknown. *Perisphinctes (Dichotomosphinctes) wartae* has also been recorded from the Transversarium Zone (ATROPS & MELENDEZ, 1993; ZEISS, 2003; MELENDEZ *et al.*, 2009). Most recently, ENAY (2009, p. 61) regarded the *Dichotomosphinctes wartae-Proscaphites anar* Zone of COLLIGNON (1959b) as equivalents of the Plicatilis and Transversarium zones and the Rauracian of the Upper Oxfordian. Nevertheless, the zones and stages described by COLLIGNON (1959a, b) from Madagascar contain components of several zones and need to be reinvestigated.

Depending on the ammonites so far described from this level, its age can be considered from different angles.

A. The genus *Peltoceratoides* occurs almost worldwide and its upper limit seems to be restricted to the Cordatum Zone (compare SANDOVAL *et al.*, 2001; PARENT *et al.*, 2006; ALBERTI *et al.*, 2011). However, some of the co-occurring perisphinctid taxa in this level have

been recorded by COLLIGNON (1959b) from horizons in Madagascar to which he assigned a younger age. However, the ammonite zonation of COLLIGNON (1959a, b) has to be considered with caution, since he recorded taxa such as *P. (D.) sparsicostatus* from the same level as *P. (Dichotomoceras) stenocycloides*, which in the present study has been found to occur quite disconnected and in a much higher horizon (i.e., lower Bifurcatus Zone, Late Oxfordian). Except for the long-ranging *P. (K.) subevolatus* all perisphinctid taxa described from Level (2) occur only together with *Peltoceratoides* and not separately in higher horizons. If it is accepted that the earlier age assignments by COLLIGNON (1959b) from Madagascar are imprecise, the whole level can be exclusively assigned to the Cordatum Zone.

- B. The autochthonous occurrences of the Early Oxfordian genus *Peltoceratoides* together with ammonites previously described from younger horizons by COLLIGNON (1959b) in a single bed might point to sediment starvation and condensation leading to an accumulation of fossils from different ammonite zones in close stratigraphic proximity. This situation would indicate that both, Cordatum and Early Plicatilis zones, are present in a single, approximately 20 cm thick horizon. However, no distinct signs of condensation, such as the existence of hardgrounds, iron crusts, or the co-occurrence of fossils with different taphonomic signatures, can be seen.
- C. The occurrence of several perisphinctid taxa, previously assigned to a younger time interval by COLLIGNON (1959b), is given priority and the whole horizon belongs to the Early Plicatilis Zone. This would imply that the genus *Peltoceratoides* has a longer stratigraphic range in the Kachchh Basin than in other parts of the world (e.g., compare SANDOVAL *et al.*, 2001; PARENT *et al.*, 2006).

Since there are points speaking against each of the interpretations, the level has been assigned only tentatively to the Cordatum / Early Plicatilis zones. Further studies including species of additional ammonite genera might give a more complete picture. A thorough reinvestigation of the ammonite record from Madagascar including new collections of higher stratigraphic resolution would also contribute greatly.

(3) Concretionary slabs in the Dhosa Conglomerate Bed (Cordatum / Early Plicatilis zones)

Concretionary slabs floating in the matrix of the Dhosa Conglomerate Bed are a typical feature of this unit (ALBERTI *et al.*, 2012). Such slabs, which occasionally reach a size of more than one metre, have been reworked from underlying strata. Their large size speaks against transport for long distances, but suggests that they are derived from the Dhosa Oolite below the Dhosa Conglomerate Bed.

Five taxa of perisphinctids have been recorded from these reworked, concretionary slabs: *P. (K.) nerunaensis*, *P. (K.) subevolutus*, *P. (A.) cf. colei*, *P. (A.) kheraensis*, and *P. (A.) cf. trifidus*. All these taxa have also been recorded from underlying strata. Additionally, ALBERTI *et al.* (2011) described *Peltoceratoides* from a concretionary slab in the Dhosa Conglomerate Bed of the Jara Dome. Therefore it seems most likely that the ammonite fauna collected from the reworked, concretionary slabs are of the same age as Level (2). Thus, the same set of problems as discussed above exists here and the preliminary age assignment is Cordatum / Early Plicatilis zones.

A special situation can be seen at Rudra Mata (Habo Dome). At this outcrop a relatively thin layer of oolitic, fine-grained sandstone covers the Dhosa Conglomerate Bed. Although it seems to be continuous, ammonite evidence proves that this layer is indeed older than the conglomeratic matrix below. ALBERTI *et al.* (2011) described a specimen of *Peltoceratoides* from this horizon. Additionally, *P. (K.) subevolutus*, *P. (A.) cf. colei*, and *P. (A.) cf. trifidus* have been recorded from this bed. These occurrences seem to indicate that this thin layer has the same age as the concretionary slabs floating in the Dhosa Conglomerate Bed.

(4) Matrix of the Dhosa Conglomerate Bed (Cordatum – Transversarium zones)

The matrix of the Dhosa Conglomerate Bed contains reworked ammonites mixed from several zones. ALBERTI *et al.* (2011) recorded several specimens of *Peltoceratoides* from this unit belonging to the Early Oxfordian Cordatum Zone. Additionally, seventeen taxa of the genus *Perisphinctes* have been identified in the present study (Fig. 66). Most of these already occur in beds underneath the Dhosa Conglomerate Bed (Levels 1 and 2) or in the concretionary slabs (Level 3). Only the following six taxa appear first in this unit: *P. (Arisphinctes) aff. cotovuiformis*, *P. sp. cf. P. (Dichotomosphinctes) antecedens*, *P. (D.) subhelenae*, *P. (D.) cf. subhelenae*, *P. sp. cf. P. (D.) wartae*, and *P. (D.) cf. tizianiformis*. These taxa clearly represent the Middle Oxfordian Plicatilis and Transversarium zones (ENAY, 2009, p. 61). Similar or closely related specimens, identified as *P. (Dichotomosphinctes) subhelenae*, *P. (D.) aff. wartae*, and *P. (D.) tizianiformis*, have been collected from the Kantkote Ammonite Beds (Fig. 66), where they occur together with index fossils such as *P. (Arisphinctes) cotovuiformis* characteristic of the Transversarium Zone (see below).

This unit has been deposited during sediment starvation on the Kachchh Mainland and is characterized by several phases of bioturbation, reworking, cementation, and dissolution. The thickness of the unit varies considerably from outcrop to outcrop. Close to Jhura Camp, Jhura Dome, it is almost absent, only filling depressions on the surface of the sandstone bed directly underneath. A few kilometres further to the west at Medisar, Jhura Dome, it

reaches around 1 metre in thickness (compare ALBERTI *et al.*, 2012).

(5) Southernmost Khadir Island (Cordatum – Transversarium zones)

The outcrops at the southernmost tip of Khadir Island are not very rich in ammonites. Nevertheless, several, identifiable specimens have been collected. Four taxa of the genus *Perisphinctes* are recorded: *P. (Perisphinctes) indogermanus*, *P. (K.) nerunaensis*, *P. (D.) cf. obliqueplicatus*, and *P. (D.) rotiformis*. While the latter three taxa have been recorded already from levels (1) to (4), *P. (Perisphinctes) indogermanus* has been collected from the Kantkote Ammonite Beds (Level 7) together with taxa such as *P. (A.) cf. cotovuiformis* or *P. (Dichotomosphinctes) aff. aeneas* characteristic of the Middle Oxfordian Transversarium Zone (OLORIZ *et al.*, 2008; ENAY, 2009). ALBERTI *et al.* (2011) described a specimen of *Peltoceratoides* from the top of the section at the same locality representing the Early Oxfordian Cordatum Zone. This specimen and also the perisphinctids described here show signs of reworking (compare ALBERTI *et al.*, 2011, fig. 4a, b). The conglomeratic bed from which these perisphinctids have been collected could therefore be a horizon time-equivalent to the Dhosa Conglomerate Bed on the Kachchh Mainland.

(6) Lower part of the Kantkote Ammonite Beds (Early Plicatilis Subzone, Plicatilis Zone)

The Kantkote Ammonite Beds are well exposed southwest of Kantkote Village and along the Trama River in the Wagad Uplift. The lower part of this unit contains *P. (K.) subevolutus*, *P. (Arisphinctes) cf. subcolubrinus*, and *P. (D.) tizianiformis*. While *P. (K.) subevolutus* is a long-ranging taxon occurring already together with Early Oxfordian species of the Cordatum Zone, the stratigraphic range of the latter two taxa is much more confined. *P. (D.) tizianiformis* has been described from Middle Oxfordian (Plicatilis Zone) rocks of Portugal (CHOFFAT, 1893). *P. (A.) subcolubrinus* has been described from the Kantkote Sandstone (WAAGEN, 1875c; SPATH, 1931a) and also from the Transversarium Zone of Poland, Portugal, and Uzbekistan (KOBAYASHI, 1947; KIM *et al.*, 2007). SPATH (1931a, p. 433) considered it to be possibly from the Bimammatum Zone. On the basis of the collected specimens of *P. (D.) cf. tizianiformis* in the matrix of the Dhosa Conglomerate Bed (Level 4) and the abundant ammonites of the Plicatilis Zone in overlying horizons, the present level should belong to the Early Plicatilis Subzone.

(7) Central part of the Kantkote Ammonite Beds (Plicatilis – Parandieri subzones, Plicatilis – Transversarium zones)

This level consists of the most fossiliferous horizons of the Kantkote Ammonite Beds. Ten taxa of the genus *Perisphinctes* have been collected from this interval

of which several are index fossils. *P. (Arisphinctes) chloroolithicus* has been previously recorded from the Antecedens Subzone, Plicatilis Zone (GYGI, 2001, p. 60; ARKELL, 1938, p. 95). *P. (Perisphinctes) martelli* has been described from horizons yielding ammonites of the Parandieri Subzone, Transversarium Zone (ENAY, 1966, p. 585). *P. (Arisphinctes) plicatilis* is a zonal ammonite of the Plicatilis Zone (CARIOU, 1966; ENAY *et al.*, 1971; CARIOU *et al.*, 1991, 1997). *P. (Dichotomosphinctes) aeneas* has been described from the *Dichotomosphinctes wartae-Proscaphites anar* Zone by COLLIGNON (1959b) and from the Transversarium Zone (OLÓRIZ *et al.*, 2008). The variety of *P. (Dichotomosphinctes) wartae* described by COLLIGNON (1959b) occurs in the *Dichotomosphinctes wartae-Proscaphites anar* Zone. The species has also been recorded from the Parandieri Subzone, Transversarium Zone (ENAY, 1966, p. 585). *P. (Dichotomosphinctes) tizianiformis* has been originally described from the Plicatilis Zone (CHOFFAT, 1893).

The long-ranging *P. (Kranaosphinctes) subevolatus* makes its last appearance at this level. Additionally, *P. (Perisphinctes) indogermanus*, *P. (Arisphinctes) cf. cotovuiformis*, and *P. (Dichotomosphinctes) subhelenae* have been recorded.

The great similarity of the inner whorls of *P. (A.) plicatilis*, *P. (P.) martelli*, *P. (A.) chloroolithicus*, and *P. (D.) subhelenae* (as discussed above), which occur in high numbers together with *P. (A.) cf. cotovuiformis*, *P. (D.) wartae*, and *P. (D.) aff. aeneas*, suggest the assignment of this level to the Plicatilis and Transversarium zones. The boundary between the two zones cannot be drawn at the present.

(8) Top part of the Kantkote Ammonite Beds (Stenocycloides Subzone, Bifurcatus Zone)

This level forms the top of the Kantkote Ammonite Beds in the sections near Kantkote Village and in the Tramu River. Sixteen perisphinctid taxa have been recorded from this horizon. Two poorly preserved specimens (GZN2010I 083, 093) identified as *P. (A.) chloroolithicus* may indicate the range of this species into the early Bifurcatus Zone.

The following taxa are restricted to this level: *P. (Perisphinctes) sp.*, *P. (Kranaosphinctes) pagri*, *P. (Arisphinctes) sp. cf. P. calvus*, *P. (Arisphinctes) kantkotensis*, *P. (Arisphinctes) kachchensis*, *P. (Dichotomosphinctes) elisabethae*, *P. (Dichotomosphinctes) aff. gamelai*, *P. (Dichotomosphinctes) aff. lehmani*, *P. (Dichotomoceras) cf. virguloides*, *P. sp. cf. P. (Dichotomoceras) bifurcatoides*, *P. (Dichotomoceras) cf. bifurcatus*, *P. (Dichotomoceras) gr. crassus*, *P. (Dichotomoceras) cf. dichotomus*, *P. (Dichotomoceras) stenocycloides*, and *P. (Dichotomoceras) cf. stenocycloides*. Most of these taxa are typical representatives of the Stenocycloides Subzone, Bifurcatus Zone (compare ENAY, 1966, p. 585;

ENAY *et al.*, 1971; CARIOU *et al.*, 1997). In addition to *P. (Dichotomoceras) stenocycloides*, the first appearance of *P. (Dichotomoceras) bifurcatoides* also indicates the beginning of the Stenocycloides Zone (GLOWNIAK *et al.*, 2010).

The new species recorded from this level, *P. (Arisphinctes) kantkotensis*, shows a high similarity to *P. (Arisphinctes) kheraensis*, which occurs in the Cordatum Zone of Kachchh Mainland and might belong to the same lineage.

In the present study, *P. (A.) kachchensis* has been recorded exclusively from this level belonging to the lower Bifurcatus Zone. SPATH (1931a, p. 416) considered specimens identified as *Perisphinctes plicatilis* by WAAGEN (1875c; collected from the Kantkote Sandstone near Kantkote Village, in the Tramu River, near Bharodia, east of Jhuran, and on Gangta Bet) to belong to his *Perisphinctes orientalis* [= *P. (A.) kachchensis*]. Although there is a similarity in the ornamentation of the inner whorls of both species, they can be easily differentiated by the outer whorls which are compressed in *plicatilis* and depressed in *kachchensis* (see also description above). Many previous workers have mentioned other species occurring in older horizons of the sedimentary succession of the Kachchh Basin as variants of SPATH's *orientalis*, e.g. *Perisphinctes helenae* (ZITTEL, 1898-1899), but they are different species occurring at different levels. *Perisphinctes orientalis* [= *P. (A.) kachchensis*] has been described from the Upper Oxfordian of the Attock District (north-western Punjab Province, Pakistan) by SPATH (1934) and from the *Dichotomosphinctes wartae-Proscaphites anar* Zone in Madagascar (COLLIGNON, 1959b). Based on the confined occurrence of this species together with abundant ammonites from the Stenocycloides Subzone, Bifurcatus Zone, it can be designated to this level in the Kachchh Basin.

(9) Patasar Shale member (?Grossouvrei Subzone, Bifurcatus Zone)

This level is represented by a single, rather poorly preserved specimen of *P. (Dichotomoceras) cf. besairiei* collected by the Late John H. CALLOMON from the Patasar Shale member about 7 to 9 m above the highest bed of the Kantkote Ammonite Beds near Kantkote Village. This species has originally been described by COLLIGNON (1959b) from Madagascar, but the biostratigraphic resolution of his material is rather poor. Due to the position of the specimen considerably above the Kantkote Ammonite Beds, it might already represent the Grossouvrei Subzone of the Upper Bifurcatus Zone. This is supported by the absence of other taxa known from the Stenocycloides Subzone. However, further ammonite specimens have to be collected and identified for a more precise and reliable age assignment.

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APPENDIX

Measurements of specimens are given in millimetres. The measurements and abbreviations are explained in Fig. 4. Numbers in parantheses are proportional dimensions as percentage of diameter.

Table 2: Dimensions of *Perisphinctes* (*Perisphinctes*) *indogermanus* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 158	68.5	17.2 (25)	24.0 (35)	35.1 (51)	0.72
OUMNH JY.1161	63	20 (32)	-	31 (49)	-
GZN2010I 073	48.8	12.5 (26)	16.1 (33)	25.2 (52)	0.78
GZN2010I 073	38.5	11.0 (29)	15.1 (39)	17.5 (45)	0.73
<i>P. indogermanus</i> WAAGEN (1875c, p. 186)	140	35 (25)	41 (29)	74 (53)	0.85
<i>P. cf. indogermanus</i> WAAGEN (SPATH, 1934, p. 5)	105	26 (25)	30 (29)	58 (55)	0.86
<i>P. indogermanus</i> WAAGEN (1875c, p. 186)	100	24 (24)	33 (33)	64 (64)	0.73

Table 3: Dimensions of *Perisphinctes* (*Perisphinctes*) *martelli* (OPPEL, 1863).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 189	88.6	21.4 (24)	~25.0 (28)	46.9 (53)	~0.86
GZN2010I 238	84.4	23.9 (28)	22.6 (27)	42.5 (50)	1.06
GZN2010I 189	71.5	18.0 (25)	22.8 (32)	37.5 (52)	0.79
GZN2010I 238	62.9	18.0 (29)	19.2 (31)	29.8 (47)	0.94
GZN2010I 238	47.8	15.2 (32)	15.6 (33)	20.4 (43)	0.97
GZN2010I 252	39.0	12.8 (33)	13.0 (33)	16.5 (42)	0.98
GZN2010I 238	35.7	12.2 (34)	13.0 (36)	14.2 (40)	0.94
GZN2010I 215	29.6	9.2 (31)	11.7 (40)	12.8 (43)	0.79
GZN2010I 152	28.1	9.2 (33)	-	11.3 (40)	-
GZN2010I 238	26.0	9.3 (36)	9.4 (36)	8.4 (32)	0.99
GZN2010I 238	18.4	8.3 (45)	8.7 (47)	-	0.95
GZN2010I 238	-	3.0	5.3	-	0.57
<i>P. (P.) martelli</i> (OPPEL) (ENAY, 1966, p. 373)	200	47 (24)	58 (29)	116 (58)	0.81
<i>P. (P.) martelli</i> (OPPEL) (ENAY, 1966, p. 373)	160	47 (29)	-	83 (52)	-
<i>P. (P.) martelli</i> (OPPEL) (ENAY, 1966, p. 373)	88	24 (27)	-	45 (51)	-
<i>Dichotomoceras predivisum</i> SPATH (1931a, p. 422).	98	29 (30)	31 (32)	47 (48)	0.94

Table 4: Dimensions of *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* (SPATH, 1931).

	D	Wh	Ww	U	Wh/Ww
OUMNH JY.348	112	29 (26)	30 (27)	~50 (45)	0.97
GZN2009II 025	110.8	26.6 (24)	31.9 (29)	59.8 (54)	0.83
OUMNH JY.526	92	23 (25)	23 (25)	50 (54)	1.00
OUMNH JY.527	84	20 (24)	21 (25)	45 (54)	0.95
GZN2010I 1089	68.5	18.3 (27)	19.4 (28)	35.5 (52)	0.94
GZN2009II 007	67.8	16.4 (24)	18.0 (27)	35.7 (53)	0.91
OUMNH JY.1160	67	16 (24)	18 (27)	-	0.89
GZN2009II 164	65.0	17.2 (26)	19.8 (30)	32.1 (49)	0.87
GZN2010I 1085	-	15.2	17.1	-	0.89
GZN2009II 198	55.8	14.8 (27)	17.3 (31)	28.3 (51)	0.86
GZN2009II 006	54.1	13.4 (25)	16.1 (30)	27.9 (52)	0.83
GZN2009II 071	50.7	12.6 (25)	13.9 (27)	26.8 (53)	0.91
GZN2009II 196	50.5	14.3 (28)	13.4 (27)	25.2 (50)	1.07

	D	Wh	Ww	U	Wh/Ww
GZN2009II 071	39.5	11.4 (29)	11.0 (28)	19.3 (49)	1.04
GZN2009II 196	38.0	11.0 (29)	11.4 (30)	17.3 (46)	0.96
GZN2009II 071	30.1	9.0 (30)	10.9 (36)	13.1 (44)	0.83
GZN2009II 196	28.2	9.8 (35)	9.9 (35)	11.0 (39)	0.99
GZN2010I 1085	-	8.1	10.8	-	0.75
GZN2009II 071	22.8	8.0 (35)	9.1 (40)	9.2 (40)	0.88
GZN2009II 196	19.6	7.4 (38)	9.7 (49)	-	0.77
GZN2009II 071	16.3	5.5 (34)	9.0 (55)	-	0.61
<i>Pachyplanulites nerunaensis</i> SPATH (1931a, p. 430)	83	19 (23)	23 (28)	46 (56)	0.83
<i>P. aberrans</i> WAAGEN (1875c, p. 175)	165	38 (23)	40 (24)	98 (59)	0.95
<i>P. aberrans</i> WAAGEN (1875c, p. 175)	75	29 (39)	~25 (33)	39 (52)	1.16

Table 5: Dimensions of *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 081	-	38.9	39.4	-	0.99
GZN2010I 096	94.3	25.8 (27)	40.3 (43)	44.0 (47)	0.64
GZN2010I 090	93.0	24.7 (27)	34.6 (37)	46.1 (50)	0.71
OUMNH JY.1178	-	23	36	-	0.64
GZN2010I 081	-	21.4	28.3	-	0.76
GZN2010I 084	-	19.1	33.0	-	0.58
GZN2010I 087	67.7	19.1 (28)	31.4 (46)	33.7 (50)	0.61
OUMNH JY.1168	53	18 (33.9)	21 (39.6)	21 (39.6)	0.85
GZN2010I 087	52.1	15.4 (30)	22.0 (42)	25.2 (48)	0.70
OUMNH JY.1168	52	17.5 (33.6)	21.6 (41.5)	21.7 (41.7)	0.81
OUMNH JY.1168	49.5	16.5 (33.3)	21.7 (43.8)	22 (44.4)	0.76
GZN2010I 084	-	12.3	22.7	-	0.54
GZN2011I 339	-	12.1	22.5	-	0.54
GZN2010I 087	39.3	11.6 (30)	16.4 (42)	~19.0 (48)	0.71
GZN2010I 133	-	10.4	18.3	-	0.57
GZN2010I 119	31.7	9.0 (28)	13.7 (43)	14.6 (46)	0.66
GZN2010I 087	-	~8.7	12.9	-	0.67
GZN2010I 119	-	7.3	12.5	-	0.58
GZN2010I 087	-	6.1	10.0	-	0.61
<i>P. pagi</i> WAAGEN (1875c, p. 182)	107	28 (26)	34 (32)	55 (51)	0.82
<i>Pachyplanulites pagi</i> (WAAGEN) (SPATH, 1931a, p. 431)	93	26 (28)	36 (39)	47 (51)	0.72
<i>P. pagi</i> WAAGEN (1875c, p. 182)	77	21 (27)	28 (36)	40 (52)	0.75
<i>Kranaosphinctes</i> (<i>Pachyplanulites</i>) <i>praeevolatus</i> COLLIGNON (1959b, pl. 75, fig. 313)	85	24 (28)	28 (33)	45 (53)	0.85
<i>Kranaosphinctes</i> (<i>Pachyplanulites</i>) <i>roedereri</i> COLLIGNON (1959b, pl. 72, fig. 307)	143	42 (29)	48 (34)	76 (53)	0.87

Table 6: Dimensions of *Perisphinctes* (*Kranaosphinctes*) *subevolutus* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 208	-	26.6	32.8	-	0.81
GZN2010I 1029	-	25.1	29.7	-	0.85
GZN2010I 1030	-	22.4	26.8	-	0.84
GZN2009II 072	92.4	20.6 (22)	25.6 (28)	53.2 (58)	0.80
GZN2009II 234	-	18.4	23.8	-	0.77
GZN2010I 1097	-	18.0	23.4	-	0.77
GZN2010I 067	72.7	17.9 (25)	25.5 (35)	38.7 (53)	0.70
GZN2009II 070	-	16.8	20.4	-	0.82
GZN2010I 227	64.7	16.4 (25)	22.3 (34)	31.8 (49)	0.74
GZN2009II 209	64.2	14.7 (23)	21.6 (34)	-	0.68
OUMNH JY.884	54	17 (31)	20 (37)	23 (43)	0.85
GZN2009II 165	51.5	15.2 (30)	20.5 (40)	25.2 (49)	0.74
GZN2009II 012	49.9	12.6 (25)	18.5 (37)	24.4 (49)	0.68
GZN2010I 210	49.7	14.6 (29)	23.0 (46)	24.8 (50)	0.63
GZN2010I 244	46.7	13.4 (29)	19.0 (41)	22.5 (48)	0.71
GZN2010I 237	44.8	14.5 (32)	21.0 (47)	19.6 (44)	0.69
GZN2010I 1083	40.2	12.5 (31)	16.5 (41)	17.4 (43)	0.76
GZN2009II 235	-	12.2	16.1	-	0.76
GZN2009II 069	-	11.6	18.3	-	0.63
GZN2010I 210	38.2	10.4 (27)	16.7 (44)	18.3 (48)	0.62
GZN2010I 244	35.6	10.8 (30)	13.5 (38)	15.9 (45)	0.80
GZN2009II 009	32.4	11.0 (34)	14.6 (45)	13.0 (40)	0.75
GZN2010I 1030	-	10.6	15.5	-	0.68
GZN2009II 233	32.2	9.8 (30)	12.4 (39)	14.5 (45)	0.79
GZN2009II 210	30.4	10.6 (35)	13.9 (46)	11.7 (38)	0.76
GZN2010I 210	29.9	9.6 (32)	14.0 (47)	13.0 (43)	0.69
GZN2010I 240	29.9	7.8 (26)	~12.5 (42)	13.2 (44)	~0.62
GZN2009II 026	27.7	8.5 (31)	11.3 (41)	12.5 (45)	0.75
GZN2010I 244	26.7	9.1 (34)	12.6 (47)	11.2 (42)	0.72
GZN2010I 1018	26.0	7.7 (30)	12.1 (47)	-	0.64
GZN2009II 001	25.8	7.2 (28)	10.2 (40)	13.3 (52)	0.71
GZN2009II 069	25.3	7.2 (28)	11.8 (47)	11.8 (47)	0.61
GZN2010I 1020	25.1	7.7 (31)	11.6 (46)	11.9 (47)	0.66
GZN2009II 078	-	7.5	11.0	-	0.68
GZN2010I 210	22.9	7.3 (32)	11.0 (48)	9.9 (43)	0.66
GZN2009II 246	22.6	6.4 (28)	11.5 (51)	10.5 (46)	0.56
GZN2009II 014	20.1	6.3 (31)	~10.4 (52)	9.4 (47)	~0.61
GZN2010I 244	19.6	6.7 (34)	9.2 (47)	8.5 (43)	0.73
GZN2010I 071	-	6.8	10.6	-	0.64
GZN2009II 068	19.3	6.8 (35)	10.3 (53)	7.0 (36)	0.66
GZN2009II 008	-	6.0	8.5	-	0.71
GZN2010I 1023	19.0	4.7 (25)	7.9 (42)	-	0.59
GZN2010I 210	17.0	5.8 (34)	8.2 (48)	7.1 (42)	0.71
GZN2010I 244	14.2	4.6 (32)	6.8 (48)	5.9 (42)	0.68
GZN2010I 210	12.6	4.3 (34)	7.7 (61)	4.4 (35)	0.56
GZN2010I 244	10.8	3.7 (34)	5.5 (51)	-	0.67
GZN2010I 210	9.0	3.9 (43)	6.1 (68)	-	0.64
<i>Kranaosphinctes</i> (<i>Pachyplanulites</i>) <i>subevolutus</i> WAAGEN (COLLIGNON, 1959b, pl. 89, fig. 352)	94	31 (33)	35 (37)	43 (46)	0.88
<i>Kranaosphinctes</i> (<i>Pachyplanulites</i>) <i>subevolutus</i> WAAGEN (COLLIGNON, 1959b, pl. 89, fig. 352)	62	22 (32)	27 (39)	33 (48)	0.81
<i>P. subevolutus</i> WAAGEN (1875c, p. 179)	56	16 (29)	21 (38)	27 (48)	0.76
<i>Subgrossouvria morley-daviesi</i> SPATH (1931a, p. 376)	75	22.5 (30)	24 (32)	36 (48)	0.94

Table 7: Dimensions of *Perisphinctes* (*Arisphinctes*) sp. cf. *Perisphinctes calvus* (J. DE C. SOWERBY, 1840).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 127	-	68.0	54.6	-	1.25
GZN2010I 106	-	25.2	28.2	-	0.89
<i>P. calvus</i> J. DE C. SOWERBY (WAAGEN, 1875c, p. 167)	182	54 (30)	45 (25)	85 (47)	1.20

Table 8: Dimensions of *Perisphinctes* (*Arisphinctes*) *chloroolithicus* (GÜMBEL, 1865).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 172	-	33.2	30.4	-	1.09
GZN2010I 183	122.3	31.9 (26)	28.7 (23)	60.4 (49)	1.11
GZN2010I 076	-	26.1	24.7	-	1.06
GZN2010I 213	-	25.3	26.7	-	0.95
GZN2010I 156	71.1	21.9 (31)	-	30.8 (43)	-
GZN2010I 260	58.8	19.2 (33)	-	25.5 (43)	-
GZN2010I 163	-	19.0	19.5	-	0.97
GZN2010I 093	-	17.4	18.4	-	0.95
GZN2010I 161	55.0	17.0 (31)	-	23.7 (43)	-
GZN2010I 157	53.0	16.4 (31)	14.4 (27)	21.9 (41)	1.14
GZN2010I 206	47.5	14.9 (31)	15.4 (32)	24.0 (51)	0.97
GZN2010I 204	41.7	12.0 (29)	14.0 (34)	18.8 (45)	0.86
GZN2010I 185	41.4	13.8 (33)	16.1 (39)	17.5 (42)	0.86
GZN2010I 177	40.2	13.7 (34)	15.4 (38)	17.7 (44)	0.89
GZN2010I 080	-	13.7	14.0	-	0.98
GZN2010I 186	34.1	10.4 (30)	14.1 (41)	15.9 (47)	0.74
GZN2010I 177	-	9.5	13.2	-	0.72
<i>P. (P.) chloroolithicus</i> (GÜMBEL) (ARKELL, 1938, p. 96)	318	70 (22)	108 (34)	191 (60)	0.65
<i>P. (P.) chloroolithicus</i> (GÜMBEL) (ARKELL, 1938, p. 97)	150	42 (28)	41 (27)	77 (51)	1.04
<i>P. (P.)</i> cf. <i>chloroolithicus</i> (GÜMBEL) (ENAY, 1966, p. 364)	120	35 (29)	32 (27)	58 (48)	1.09
<i>P. (P.) chloroolithicus</i> (GÜMBEL) (ARKELL, 1938, p. 97)	86	29 (34)	27 (32)	37 (43)	1.06
<i>P. (P.) chloroolithicus</i> (GÜMBEL) (ARKELL, 1938, p. 96)	50	18 (36)	17 (33)	19 (38)	1.09
<i>P. (Dichotomoceras) bifurcatus</i> (QUENSTEDT) (ENAY, 1966, p. 505)	80	27 (34)	18.5 (23)	42 (53)	1.46
<i>Dichotomosphinctes falcuiae</i> (RONCHANDZÉ) (SPATH, 1931a, p. 435)	63	21 (33)	19 (30)	26 (41)	1.11

Table 9: Dimensions of *Perisphinctes* (*Arisphinctes*) cf. *colei* SPATH, 1931.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 1071	-	34.3	33.0	-	1.04
GZN2009II 027	115.1	32.0 (28)	~30.0 (26)	60.2 (52)	~1.07
GZN2010I 1069	-	30.2	28.5	-	1.06
GZN2010I 1068	-	24.2	22.5	-	1.08
GZN2009II 203	-	23.5	23.1	-	1.02
GZN2010I 1069	-	18.6	19.4	-	0.96
GZN2010I 1004	-	18.2	16.5	-	1.10
GZN2009II 191	68.5	17.5 (26)	~20.0 (29)	33.0 (48)	~0.88
GZN2010I 1068	-	12.7	14.3	-	0.89
<i>P. colei</i> SPATH (1931a, p. 421)	100	25 (25)	27 (27)	53 (53)	0.93
<i>P. indogermanus</i> WAAGEN (1875c, p. 186)	140	35 (25)	41 (29)	74 (53)	0.85
<i>P. indogermanus</i> WAAGEN (1875c, p. 186)	100	24 (24)	33 (33)	64 (64)	0.73

Table 10: Dimensions of *Perisphinctes* (*Arisphinctes*) cf. *cotovuiiformis* ENAY, 2009.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 257	345.0	71.5 (21)	~70 (20)	210.0 (61)	~1.02
GZN2010I 257	290.5	60.0 (21)	~55 (19)	180.0 (62)	~1.09
<i>P. (Arisphinctes) cotovui</i> SIMIONESCU (ARKELL, 1939, p. 127; syn. after ENAY, 2009)	400	92 (23)	86 (21.5)	240 (60)	1.07
<i>P. (Perisphinctes) parandieri</i> DE LORIO (ARKELL, 1939, p. 105)	330	76 (23)	79 (24)	198 (60)	0.96
<i>P. (Perisphinctes) ingens</i> BUCKMAN (ARKELL, 1939, p. 105)	336	91 (27)	67 (20)	181 (54)	1.36
<i>P. (Arisphinctes) pickeringius</i> (YOUNG & BIRD) (ARKELL, 1939, p. 134)	350	82 (23.5)	75 (21.5)	207 (59)	1.09

Table 11: Dimensions of *Perisphinctes* (*Arisphinctes*) aff. *cotovuiiformis* ENAY, 2009.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 207	79.5	22.5 (28)	25.2 (32)	41.0 (52)	0.89
<i>P. (Arisphinctes) cotovui</i> SIMIONESCU (ARKELL, 1939, p. 127; syn. after ENAY, 2009)	100	30 (30)	29 (29)	45 (45)	1.04
<i>P. (Arisphinctes) cotovui</i> SIMIONESCU (ARKELL, 1939, p. 127; syn. after ENAY, 2009)	75	25 (33)	25 (33)	34 (45)	1.00
<i>P. (Arisphinctes) cotovui</i> SIMIONESCU (ARKELL, 1939, p. 127; syn. after ENAY, 2009)	50	18.5 (37)	19 (38)	21 (42)	0.97
<i>P. (Arisphinctes) pickeringius</i> (YOUNG & BIRD) (ARKELL, 1939, p. 134)	85	27 (32)	25.5 (30)	36.5 (43)	1.07

Table 12: Dimensions of *Perisphinctes* (*Arisphinctes*) *kantkotensis* sp. nov.

	D	Wh	Ww	U	Wh/Ww
GZN2011I 347 (Holotype)	280	80 (29)	74 (26)	140 (50)	1.08

Table 13: Dimensions of *Perisphinctes* (*Arisphinctes*) *kheraensis* SPATH, 1931.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 060	122.0	35.3 (29)	33.4 (27)	61.3 (50)	1.06
GZN2009II 195	-	21.5	23.5	-	0.91
GZN2009II 163	64.6	15.2 (24)	20.1 (31)	35.4 (55)	0.76
GZN2010I 1014	54.4	16.5 (30)	19.5 (36)	23.8 (44)	0.85
GZN2009II 011	49.0	12.5 (26)	16.6 (34)	23.0 (47)	0.75
OUMNH JY.533	42	13 (31)	15 (36)	18 (43)	0.87
GZN2010I 1049	-	11.7	13.4	-	0.87
GZN2010I 272	-	10.5	13.0	-	0.81
GZN2009II 010	38.1	10.4 (27)	13.4 (35)	18.6 (49)	0.78
GZN2009II 076	17.2	7.1 (41)	8.0 (47)	6.1 (35)	0.89
<i>P. kheraensis</i> SPATH (1931a, p. 420)	107	28 (26)	26 (24)	58 (54)	1.08
<i>Subgrossouvria blakei</i> SPATH (1931a, p. 374)	89	27 (30)	29 (33)	47 (53)	0.91

Table 14: Dimensions of *Perisphinctes* (*Arisphinctes*) *kachchhensis* sp. nov.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 148	218.0	51.3 (24)	58.4 (27)	123.3 (57)	0.88
GZN2010I 091	200.0	50.0 (25)	56.9 (28)	109.7 (55)	0.88
GZN2011I 338	-	~44.0	54.8	-	~0.80
GZN2010I 091	169.0	42.6 (25)	47.8 (28)	92.0 (54)	0.89
GZN2010I 128	-	36.5	42.2	-	0.86
GZN2010I 085	-	31.1	34.4	-	0.90
<i>P. orientalis</i> SIEMIRADZKI (SPATH, 1931a, p. 417)	235	56 (24)	63 (27)	129 (55)	0.89
<i>P. plicatilis</i> (J. SOWERBY) (WAAGEN, 1875c, p. 190; syn. after SPATH, 1931a)	210	49 (23)	52 (25)	103 (49)	0.94
<i>P. orientalis</i> SIEMIRADZKI (SPATH, 1934, p. 4)	190	53 (28)	53 (28)	80 (50)	1.00
<i>P. plicatilis</i> (J. SOWERBY) (WAAGEN, 1875c, p. 190; syn. after SPATH, 1931a)	90	26 (29)	23 (26)	45 (50)	1.13
<i>P. plicatilis</i> (J. SOWERBY) (WAAGEN, 1875c, p. 190; syn. after SPATH, 1931a)	77	23 (30)	18 (23)	38 (49)	1.28

Table 15: Dimensions of *Perisphinctes* (*Arisphinctes*) *polymorphus* (SPATH, 1931).

	D	Wh	Ww	U	Wh/Ww
GZN2009II 016	88.0	28.0 (32)	25.7 (29)	37.3 (42)	1.09
GZN2010I 1074	52.3	18.0 (34)	14.3 (27)	19.7 (38)	1.26
GZN2010I 1081	-	16.7	14.8	-	1.13
OUMNH JY.474	47	13 (28)	13 (28)	21 (45)	1.00
GZN2009II 018	44.5	13.0 (29)	~12.0 (27)	20.2 (45)	~1.08
OUMNH JY.535	44	16 (36)	14 (32)	18 (41)	1.14
GZN2010I 1079	43.5	14.0 (32)	12.1 (28)	-	1.16
GZN2009II 017	39.8	14.0 (35)	13.1 (33)	15.0 (38)	1.07
OUMNH JY.477	39	12 (31)	-	17 (44)	-
GZN2010I 1074	37.6	13.5 (36)	12.7 (34)	14.6 (39)	1.06
OUMNH JY.480	37	12 (32)	11 (30)	15 (41)	1.09
OUMNH JY.476	36	11 (31)	11 (31)	-	1.00
OUMNH JY.478	33	10 (30)	-	15 (45)	-
GZN2009II 019	32.1	10.8 (34)	10.5 (33)	12.7 (40)	1.03
GZN2009II 020	30.2	9.3 (31)	9.6 (32)	12.3 (41)	0.97
OUMNH JY.881	29	9 (31)	~9 (31)	14 (48)	~1.00
GZN2009II 021	26.9	8.5 (32)	8.6 (32)	10.3 (38)	0.99
GZN2010I 1074	26.7	9.5 (36)	8.9 (33)	10.0 (37)	1.07
GZN2010I 1074	18.0	7.2 (40)	8.2 (46)	-	0.88
<i>Alligaticeras polymorphum</i> SPATH (1931a, p. 409)	74	23 (31)	21 (28)	33 (44)	1.10
<i>Alligaticeras polymorphum</i> SPATH (COLLIGNON 1959a, pl. 43, fig. 220)	84	26 (31)	25 (30)	42 (50)	1.03
<i>Alligaticeras</i> aff. <i>polymorphum</i> SPATH (COLLIGNON, 1959b, pl. 69, fig. 301)	67	19 (28)	19 (28)	34 (51)	1.0
<i>Alligaticeras</i> aff. <i>polymorphum</i> SPATH (COLLIGNON 1959b, pl. 69, fig. 302)	58	17 (29)	17 (29)	29 (50)	1.0

Table 16: Dimensions of *Perisphinctes* (*Arisphinctes*) cf. *subcolubrinus* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 065	-	59.9	54.8	-	1.09
GZN2010I 064	-	35.7	36.5	-	0.98
GZN2010I 234	116.0	33.1 (29)	~26.2 (23)	58.1 (50)	~1.26
GZN2010I 264	-	29.7	28.5	-	1.04
GZN2010I 064	-	22.1	24.9	-	0.89
GZN2010I 264	-	18.5	20.2	-	0.92
GZN2010I 064	-	15.0	16.5	-	0.91
<i>P. subcolubrinus</i> WAAGEN (1875c, p. 181)	97	28 (29)	28 (29)	48 (49)	1.00

Table 17: Dimensions of *Perisphinctes* (*Arisphinctes*) cf. *trifidus* J. SOWERBY, 1821.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 204	-	19.8	19.2	-	1.03
GZN2009II 114	50.5	14.2 (28)	12.0 (24)	25.9 (51)	1.18
OUMNH JY.269	50	16 (32)	-	23 (46)	-
GZN2009II 149	40.0	14.6 (37)	14.3 (36)	16.3 (41)	1.02
GZN2010I 1075	-	13.4	12.7	-	1.06
GZN2010I 1082	39.3	12.2 (31)	12.8 (33)	18.3 (47)	0.95
GZN2009II 228	28.8	10.2 (35)	10.8 (38)	~12.3 (43)	0.94
<i>P. (Arisphinctes) helenae</i> DE RIAZ (ARKELL, 1939, p. 150; syn. after GLOWNIAK, 2002)	145	35 (24)	32 (22)	78 (54)	1.09
<i>P. (Arisphinctes) helenae</i> DE RIAZ (ARKELL, 1939, p. 150; syn. after GLOWNIAK, 2002)	75	22 (29)	20 (27)	35 (47)	1.10
<i>Dichotomosphinctes helenae</i> (DE RIAZ) (SPATH, 1931a, p. 436)	73	22 (30)	20 (27)	34 (47)	1.10
<i>Dichotomosphinctes helenae</i> (DE RIAZ) (SPATH, 1931a, p. 436)	63	20 (32)	18 (29)	30 (47)	1.10
<i>P. rota</i> WAAGEN (1875c, p. 187)	154	39 (25)	35 (23)	88 (57)	1.11

Table 18: Dimensions of *Perisphinctes* (*Arisphinctes*) *rota* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
OUMNH JY.1259	146	34 (23)	35 (24)	80 (55)	0.97
GZN2009II 227	-	33.0	28.9	-	1.14
GZN2010I 1059	-	29.7	28.1	-	1.06
OUMNH JY.925	110	27 (25)	27 (25)	59 (54)	1.00
GZN2009II 227	-	14.8	~15.0	-	0.93
<i>P. rota</i> WAAGEN (1875c, p. 187)	154	39 (25)	35 (23)	88 (57)	1.11
<i>P. rota</i> WAAGEN (1875c, p. 187)	140	34 (24)	32 (23)	81 (58)	1.06
<i>Dichotomosphinctes (Otosphinctes) rota</i> WAAGEN var. <i>fasciculata</i> COLLIGNON (1959b, pl. 62, fig. 282)	148	35 (24)	41 (28)	85 (57)	0.85
<i>Dichotomosphinctes (Otosphinctes) rota</i> WAAGEN var. <i>fasciculata</i> COLLIGNON (1959b, pl. 62, fig. 282)	125	31 (25)	35 (28)	71 (57)	0.88
<i>Dichotomosphinctes (Otosphinctes) rota</i> WAAGEN var. <i>constricta</i> COLLIGNON (1959b, pl. 68, fig. 298)	98	26 (27)	26 (28)	52 (53)	1.00

Table 19: Dimensions of *Perisphinctes* (*Liosphinctes*) *plicatilis* (J. SOWERBY, 1817).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 165	139.0	39.8 (29)	31.8 (23)	66.8 (48)	1.25
GZN2010I 245	117.0	27.6 (24)	25.2 (22)	53.0 (45)	1.10
GZN2010I 198	-	25.1	22.5	-	1.12
GZN2010I 251	80.6	24.1 (30)	18.8 (23)	37.7 (47)	1.28
GZN2010I 256	78.0	23.4 (30)	19.4 (25)	36.6 (47)	1.21
GZN2010I 261	72.5	21.8 (30)	19.3 (27)	30.4 (42)	1.13
GZN2010I 253	69.0	19.9 (29)	17.0 (25)	34.8 (50)	1.17
GZN2010I 168	58.1	19.5 (34)	17.2 (30)	24.0 (41)	1.13
GZN2010I 256	57.4	18.3 (32)	16.5 (29)	25.0 (44)	1.11
GZN2010I 188	54.0	14.7 (27)	-	23.4 (43)	-
GZN2010I 191	51.5	17.3 (34)	17.0 (33)	22.5 (44)	1.02
GZN2010I 253	51.5	14.4 (28)	13.8 (27)	23.7 (46)	1.04
GZN2010I 066	51.1	18.9 (37)	-	18.5 (36)	-
GZN2010I 167	48.8	17.9 (37)	-	16.8 (34)	-
GZN2010I 218	-	16.8	15.8	-	1.06
GZN2010I 176	-	14.8	15.3	-	0.97
GZN2010I 256	42.2	14.1 (33)	13.1 (31)	17.7 (42)	1.08
GZN2010I 178	40.2	12.2 (30)	13.0 (32)	16.0 (40)	0.94
GZN2010I 253	39.0	13.6 (35)	13.3 (34)	15.8 (41)	1.02
GZN2010I 212	35.1	11.7 (33)	12.2 (35)	13.4 (38)	0.96
GZN2010I 211	35.0	10.8 (31)	12.5 (36)	14.0 (40)	0.86
GZN2010I 256	30.0	10.3 (34)	9.5 (32)	12.3 (41)	1.08
GZN2010I 193	29.9	11.0 (37)	11.4 (38)	9.7 (32)	0.96
GZN2010I 173	29.2	11.5 (39)	-	9.9 (34)	-
GZN2010I 195	29.1	10.8 (37)	-	10.3 (35)	-
GZN2010I 253	28.0	9.9 (35)	11.0 (39)	10.7 (38)	0.90
GZN2010I 242	27.3	9.8 (36)	-	9.7 (36)	-
GZN2010I 254	26.0	9.5 (37)	-	8.7 (33)	-
GZN2010I 255	26.0	9.4 (36)	10.1 (39)	11.0 (42)	0.93
GZN2010I 217	25.2	9.3 (37)	11.3 (45)	8.0 (32)	0.82
GZN2010I 220	22.8	7.8 (34)	10.6 (46)	8.7 (38)	0.74
GZN2010I 174	22.1	7.9 (36)	9.6 (43)	6.9 (31)	0.82
GZN2010I 256	21.0	7.7 (37)	7.7 (37)	8.2 (39)	1.00
GZN2010I 253	19.8	7.6 (38)	8.0 (40)	6.6 (33)	0.95
GZN2010I 216	19.4	6.8 (35)	9.4 (48)	6.5 (34)	0.72
GZN2010I 256	14.6	5.7 (39)	6.9 (47)	4.2 (29)	0.83
GZN2010I 253	13.7	5.6 (41)	6.9 (50)	-	0.81
GZN2010I 256	9.9	4.9 (49)	5.8 (59)	2.0 (20)	0.84
GZN2010I 256	6.2	3.0 (48)	5.0 (81)	-	0.60
<i>P. (Arisphinctes) plicatilis</i> (J. SOWERBY) (ARKELL, 1939, p. 145)	150	42 (28)	37.5 (25)	76.5 (51)	1.12
<i>P. (Arisphinctes) plicatilis</i> (J. SOWERBY) (ARKELL, 1939, p. 145)	100	34 (34)	28 (28)	41 (41)	1.21
<i>P. (Arisphinctes) plicatilis</i> (J. SOWERBY) (ARKELL, 1939, p. 145)	80	29 (36)	26 (32)	32 (40)	1.12
<i>P. (Arisphinctes) plicatilis</i> (J. SOWERBY) (ARKELL, 1939, p. 145)	65	25 (38)	22 (34)	24 (37)	1.14
<i>Dichotomosphinctes falculae</i> (RONCHANDZÉ) (SPATH, 1931a, p. 435)	63	21 (33)	19 (30)	26 (41)	1.11
<i>Lithacoceras (Larcheria) subschilli</i> (LEE) (ENAY, 1966, p. 530)	90	30 (33)	25 (28)	36 (40)	1.20
<i>Lithacoceras (Larcheria) subschilli</i> (LEE) (ENAY, 1966, p. 530)	71	24 (34)	-	28 (39)	-

Table 20: Dimensions of *Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomosphinctes*) *antecedens* SALFELD, 1914.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 194	-	27.1	23.5	-	1.15
GZN2009II 194	38.6	14.0 (36)	14.2 (37)	14.4 (38)	0.99
GZN2009II 013	35.1	12.0 (34)	12.8 (36)	13.0 (37)	0.94
<i>P. (Dichotomosphinctes) antecedens</i> SALFELD (ENAY, 1966, p. 473)	101	26.5 (26)	22.5 (22)	52 (51)	1.18
<i>P. (Dichotomosphinctes) antecedens</i> SALFELD (ARKELL, 1938, p. 83)	100	28 (28)	26 (26)	52 (52)	1.08
<i>P. (Dichotomosphinctes) antecedens</i> SALFELD (ARKELL, 1938, p. 84)	85	23 (27)	23 (27)	45 (53)	1.00
<i>P. (Dichotomosphinctes) antecedens</i> SALFELD (ARKELL, 1938, p. 84)	65	19 (29)	18 (27)	30 (46)	1.06
<i>P. (Dichotomosphinctes) antecedens</i> SALFELD (ENAY, 1966, p. 473)	50	15.5 (31)	15.5 (31)	24 (48)	1.00

Table 21: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ, 1898.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 146	-	42.3	34.4	-	1.23
GZN2010I 094	100.8	29.1 (29)	24.4 (24)	48.8 (48)	1.19
GZN2010I 100	67.1	20.7 (31)	20.6 (31)	31.0 (46)	1.00
GZN2010I 137	53.5	16.7 (31)	14.4 (27)	22.3 (42)	1.16
<i>P. (Dichotomosphinctes) elisabethae</i> DE RIAZ (ENAY, 1966, p. 491)	80	27 (34)	20 (25)	33.5 (42)	1.35
<i>P. (Dichotomosphinctes) elisabethae</i> DE RIAZ (GYGI, 2000, p. 83)	77	24 (31)	21 (27)	34 (44)	1.14
<i>P. leiocymon</i> WAAGEN (1875c, p. 205)	145	47 (32)	38 (26)	61 (42)	1.24

Table 22: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) cf. *gamelai* ARKELL, 1947.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 109	44.0	14.6 (33)	14.2 (32)	17.5 (40)	1.03

Table 23: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) *jacki* (SPATH, 1931).

	D	Wh	Ww	U	Wh/Ww
OUMNH JY.1137/1-2	107	27 (25)	24 (22)	58 (54)	1.13
GZN2009II 074	76.1	20.9 (27)	19.3 (25)	37.4 (49)	1.08
OUMNH JY.473	69	20 (29)	17 (25)	36 (52)	1.18
OUMNH JY.275	56	17 (30)	17 (30)	25 (45)	1.00
GZN2009II 117	51.7	16.4 (32)	15.2 (29)	22.8 (44)	1.08
GZN2010I 1051	-	16.0	15.0	-	1.07
GZN2009II 193	49.4	15.1 (31)	~14.8 (30)	23.5 (48)	~1.02
GZN2010I 1086	49.3	13.9 (28)	13.8 (28)	24.4 (49)	1.01
GZN2010I 1084	45.9	ca14 (30.5)	13.9 (30)	22.5 (49)	1.00
GZN2009II 024	44.6	13.5 (30)	13.0 (29)	21.0 (47)	1.04
GZN2009II 005	41.8	13.3 (32)	13.0 (31)	19.1 (46)	1.02
OUMNH JY.273	39	13 (33)	13 (33)	18 (46)	1.00
GZN2009II 117	37.8	12.6 (33)	12.4 (33)	15.5 (41)	1.02
GZN2009II 115	37.5	11.9 (32)	10.6 (28)	17.0 (45)	1.12
GZN2009II 116	32.8	11.0 (34)	~10.5 (32)	13.8 (42)	~1.05
GZN2009II 117	26.9	9.9 (37)	11.0 (41)	10.4 (39)	0.90
GZN2009II 117	18.7	6.7 (36)	9.0 (48)	-	0.74
<i>Otosphinctes jacki</i> SPATH (1931a, p. 414)	97	26 (27)	26 (27)	52 (54)	1.00
<i>Grossouvria evexa</i> (QUENSTEDT) (SPATH, 1931a, p. 367)	38	13 (34)	10 (26)	17 (45)	1.30

Table 24: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) cf. *obliqueplicatus* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 028	-	36.1	32.4	-	1.11
GZN2009II 028	-	24.2	21.9	-	1.11
OUMNH JY.1159	80	21 (26)	22 (28)	37 (46)	0.95
GZN2009II 189	74.5	23.4 (31)	~22.0 (30)	32.9 (44)	1.06
GZN2009II 202	-	19.5	16.5	-	1.18
GZN2009II 189	57.7	18.8 (33)	18.0 (31)	25.4 (44)	1.04
GZN2009II 119	49.6	16.0 (32)	13.1 (26)	22.0 (44)	1.22
GZN2009II 028	-	14.9	14.6	-	1.02
GZN2009II 202	-	12.5	10.5	-	1.19
GZN2009II 028	25.4	8.3 (33)	9.6 (38)	11.2 (44)	0.86
GZN2009II 028	18.6	6.1 (33)	8.4 (45)	8.2 (44)	0.73
GZN2009II 028	13.8	4.4 (32)	6.9 (50)	6.2 (45)	0.64
GZN2009II 028	10.3	3.4 (33)	5.3 (51)	4.2 (41)	0.64
GZN2009II 028	7.7	2.8 (36)	5.2 (68)	2.6 (34)	0.54
GZN2009II 028	5.9	2.3 (39)	4.2 (71)	1.9 (32)	0.55
GZN2009II 028	4.5	1.8 (40)	3.4 (76)	1.4 (31)	0.53
GZN2009II 028	3.5	1.5 (43)	2.6 (74)	0.9 (26)	0.58
GZN2009II 028	2.5	1.1 (44)	2.1 (84)	-	0.52
<i>P. obliqueplicatus</i> WAAGEN (1875c, p. 188)	76	20 (26)	16 (21)	42 (55)	1.25
<i>Alligaticeras obliqueplicatum</i> (WAAGEN) (SPATH, 1931a, p. 408)	53	16 (30)	14 (26)	27 (51)	1.14
<i>P. obliqueplicatus</i> WAAGEN (1875c, p. 188)	47	14 (30)	12 (26)	23 (49)	1.17
<i>P. obliqueplicatus</i> WAAGEN (1875c, p. 188)	34	11 (32)	9 (26)	15 (44)	1.22

Table 25: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) *rotiformis* (SPATH, 1931).

	D	Wh	Ww	U	Wh/Ww
GZN2009II 067	-	17.9	18.6	-	0.96
GZN2009II 232	34.3	9.7 (28)	11.5 (34)	17.1 (50)	0.84
<i>P. indogermanus</i> WAAGEN (1875c, pl. 48, fig. 4; holotype of <i>P. rotiformis</i> after SPATH, 1931a)	63	16 (25)	17 (27)	34 (54)	0.94
<i>P. rota</i> WAAGEN (1875c, p. 187)	154	39 (25)	35 (23)	88 (57)	1.11
<i>P. rota</i> WAAGEN (1875c, p. 187)	140	34 (24)	32 (23)	81 (58)	1.06

Table 26: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) *subhelenae* (SPATH, 1931).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 184	98.2	26.7 (27)	22.5 (23)	45.3 (46)	1.19
GZN2010I 162	93.0	27.6 (30)	22.7 (24)	45.1 (48)	1.22
GZN2010I 262	77.9	21.1 (27)	20.2 (26)	38.8 (50)	1.04
GZN2010I 190	71.3	19.1 (27)	16.6 (23)	34.8 (49)	1.15
OUMNH JY.1260	62	18 (29)	-	~27 (44)	-
GZN2010I 151	52.6	16.2 (31)	15.5 (29)	22.2 (42)	1.05
GZN2010I 200	51.7	14.6 (28)	~13.5 (26)	25.3 (49)	~1.08
OUMNH JY.1261/1	43	14 (33)	14 (33)	18 (42)	1.00
GZN2010I 151	39.4	14.2 (36)	12.6 (32)	15.1 (38)	1.13
GZN2010I 232	37.0	12.5 (34)	12.3 (33)	~17.2 (46)	1.02
GZN2010I 209	33.0	12.0 (36)	12.0 (36)	13.0 (39)	1.00
GZN2010I 151	27.9	10.1 (36)	9.4 (34)	10.7 (38)	1.07
GZN2010I 151	19.4	6.9 (36)	7.8 (40)	7.3 (38)	0.88
GZN2010I 151	13.4	5.2 (39)	6.8 (51)	4.9 (37)	0.76
GZN2010I 151	9.5	3.3 (35)	6.0 (63)	-	0.55
<i>Dichotomosphinctes subhelenae</i> SPATH (1931a, p. 437)	75	24 (32)	19 (25)	34 (45)	1.26
<i>Dichotomosphinctes subhelenae</i> SPATH (1931a, p. 437)	47	16 (34)	15 (31)	19 (41)	1.07

Table 27: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) cf. *subhelenae* (SPATH, 1931).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 1080	-	15.9	14.0	-	1.14
GZN2009II 004	45.7	14.7 (32)	15.6 (34)	19.8 (43)	0.94
GZN2010I 1076	35.8	12.2 (34)	12.9 (36)	14.1 (39)	0.95

Table 28: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) aff. *wartae* BUKOWSKI, 1887.

	D	Wh	Ww	U	Wh/Ww
OUMNH JY.1166	-	24.5	21.5	-	1.14
<i>Dichotomosphinctes wartae</i> BUKOWSKI var. <i>bedoensis</i> COLLIGNON (1959b, pl. 61, fig. 281)	165	45 (27)	32 (20)	89 (54)	1.41

Table 29: Dimensions of *Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomosphinctes*) *wartae* BUKOWSKI, 1887.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 1077	-	26.5	20.5	-	1.29
GZN2009II 237	-	20.5	17.4	-	1.18
<i>P. (Dichotomosphinctes) wartae</i> BUKOWSKI (ENAY, 1966, p. 484)	156	42 (27)	27 (17)	80 (51)	1.56
<i>P. (Dichotomosphinctes) wartae</i> BUKOWSKI (ENAY, 1966, p. 484)	100	28.5 (29)	22 (22)	50 (50)	1.30

Table 30: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) aff. *lehmani* (COLLIGNON, 1959).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 144	58.2	17.8 (31)	~19.5 (34)	24.1 (41)	~0.91
<i>Orionoides lehmani</i> COLLIGNON (1959b, pl. 59, fig. 276)	107	26 (24)	26 (24)	61 (57)	1.00
<i>Orionoides lehmani</i> COLLIGNON (1959b, pl. 60, fig. 277)	51	16 (31)	18 (35)	24 (47)	0.89

Table 31: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) aff. *aeneas* GEMMELLARO, 1872.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 169	76.9	24.1 (31)	21.9 (28)	34.3 (45)	1.10
GZN2010I 169	61.4	20.7 (34)	19.4 (32)	26.4 (43)	1.07
GZN2010I 208	49.6	16.4 (33)	-	19.7 (40)	-
GZN2010I 219	41.2	15.0 (36)	12.8 (31)	14.9 (36)	1.17
<i>Discosphinctes aeneas</i> GEMMELLARO (COLLIGNON, 1959b, pl. 76, fig. 317)	72	25 (35)	21 (29)	30 (42)	1.19
<i>Perisphinctes aeneas</i> GEMMELLARO (1872, p. 162)	107	39 (36)	28 (26)	42 (39)	1.38
<i>Lithacoceras</i> aff. <i>kreutzi</i> (SIEMIRADZKI) (SPATH, 1931a, p. 456)	50	18 (36)	13 (26)	19.5 (39)	1.38

Table 32: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) *tizianiformis* CHOFFAT, 1893.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 149	107.7	28.8 (27)	23.6 (22)	58.6 (54)	1.22
GZN2010I 171	76.3	25.4 (33)	-	31.5 (41)	-
GZN2010I 171	-	20.2	17.8	-	1.13
GZN2010I 243	58.1	16.4 (28)	14.7 (25)	25.4 (44)	1.12
<i>P. tizianiformis</i> CHOFFAT (1893, pl. 3, figs. 1, 2)	92	31 (34)	25 (27)	43 (47)	1.24
<i>Ammonites tiziani</i> OPPEL (1863, p. 246)	107	39 (36)	24 (22)	57 (53)	1.63
<i>Orthosphinctes</i> (<i>Orthosphinctes</i>) <i>polygyratus</i> (REINECKE) (SCHLEGELMILCH, 1994, p. 64)	107	33 (31)	-	53.5 (50)	-

Table 33: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) cf. *tizianiformis* CHOFFAT, 1893.

	D	Wh	Ww	U	Wh/Ww
GZN2009II 206	-	26.4	17.8	-	1.48

Table 34: Dimensions of *Perisphinctes* (*Dichotomosphinctes*) sp.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 1090	74.8	21.0 (28)	17.4 (23)	38.2 (51)	1.21
GZN2010I 1010	46.5	13.7 (29)	-	20.8 (45)	-

Table 35: Dimensions of *Perisphinctes* (*Dichotomoceras*) cf. *virguloides* WAAGEN, 1875.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 099	-	32.6	31.5	-	1.03
GZN2010I 108	-	28.2	~24.6	-	~1.15
GZN2010I 130	-	26.5	26.5	-	1.00
<i>P. virguloides</i> WAAGEN (1875c, p. 204)	118	34 (29)	28 (24)	49 (42)	1.21
<i>Prososphinctes virguloides</i> WAAGEN (SPATH, 1934, p.12)	108	32 (30)	29 (27)	52 (48)	1.11
<i>Prososphinctes virguloides</i> WAAGEN (SPATH, 1934, p.12)	92	30 (33)	24 (26)	39 (42)	1.27
<i>P. virguloides</i> WAAGEN (1875c, p. 204)	42	14 (33)	14 (33)	17 (40)	1.00

Table 36: Dimensions of *Perisphinctes* (*Dichotomoceras*) cf. *besairiei* (COLLIGNON, 1959).

	D	Wh	Ww	U	Wh/Ww
<i>Divisosphinctes besairiei</i> COLLIGNON (1959b, pl. 88, fig. 350)	102	35 (34)	31 (30)	45 (44)	1.13

Plate I

Figs. 1-4: *Perisphinctes* (*Perisphinctes*) *indogermanus* WAAGEN, 1875

- 1: lateral view of the wholly septate specimen GZN2010I 158 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm).
- 2: lateral view of the wholly septate specimen GZN2010I 073 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).
- 3: ventral view of the wholly septate specimen GZN2010I 073 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).
- 4: lateral view of the wholly septate specimen OUMNH JY.1161 from the southernmost tip of Khadir Island (scale bar = 10 mm).

Figs. 5-8: *Perisphinctes* (*Perisphinctes*) *martelli* (OPPEL, 1863)

- 5: lateral view of specimen GZN2010I 189 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm). No suture line is visible in the outer whorl.
- 6: lateral view of the wholly septate specimen GZN2010I 252 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm).
- 7: ventral view of the wholly septate specimen GZN2010I 252 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm).
- 8: ventral view of specimen GZN2010I 189 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm).

Fig. 9: *Perisphinctes* (*Perisphinctes*) sp.

- Lateral view of specimen GZN2010I 134, a fragment of a body chamber, from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 14 mm).

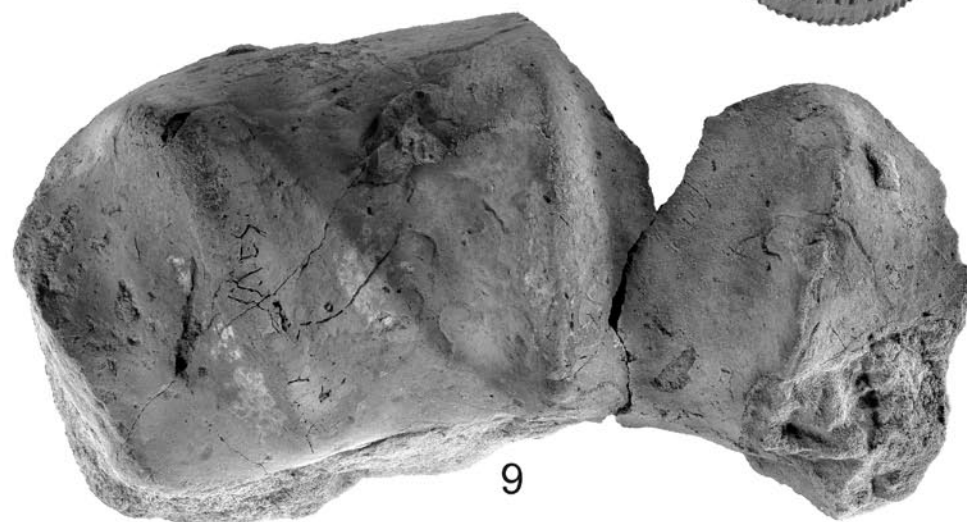
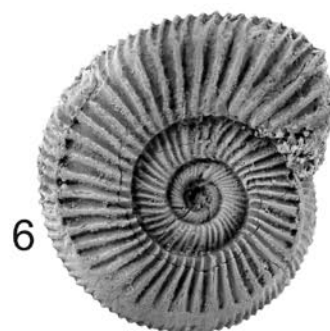
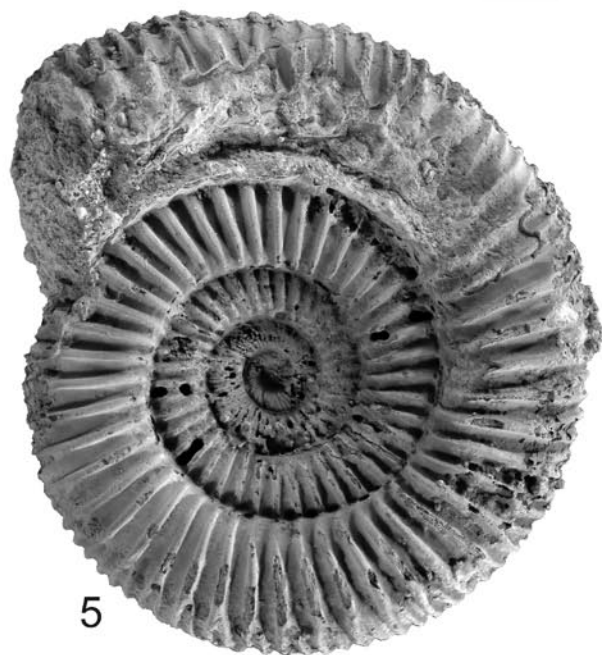
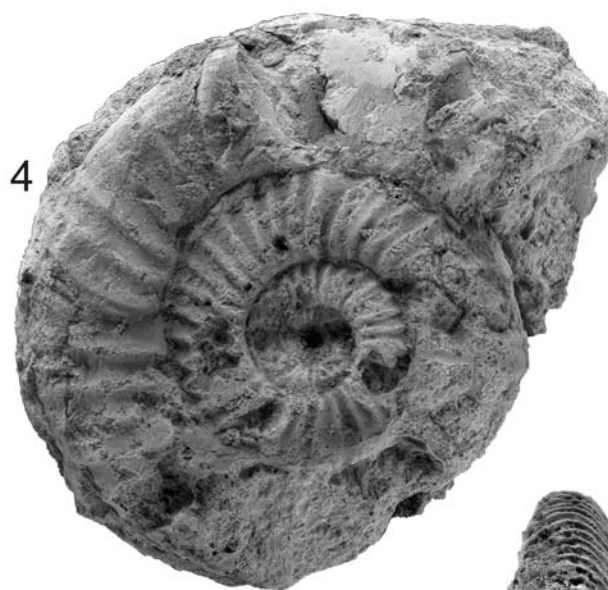


Table 37: Dimensions of *Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomoceras*) *bifurcatoides* ENAY, 1966.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 124	-	16.4	15.3	-	1.07
GZN2010I 117	-	13.3	14.4	-	0.92

Table 38: Dimensions of *Perisphinctes* (*Dichotomoceras*) cf. *bifurcatus* (QUENSTEDT, 1847).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 118	36.8	12.1 (33)	13.0 (35)	15.6 (42)	0.93
GZN2010I 123	18.5	6.1 (33)	8.4 (45)	7.8 (42)	0.73
<i>P. (Dichotomoceras) bifurcatus</i> (QUENSTEDT) (ENAY, 1966, p. 505)	55	19 (35)	17 (31)	22 (40)	1.12
<i>P. (Dichotomoceras) bifurcatus</i> (QUENSTEDT) (ENAY, 1966, p. 505)	40	14 (35)	9.5 (24)	16.5 (41)	1.47
<i>P. (Dichotomoceras) bifurcatus</i> (QUENSTEDT) (ENAY, 1966, p. 505)	31	10 (32)	9 (29)	13 (42)	1.11

Table 39: Dimensions of *Perisphinctes* (*Dichotomoceras*) gr. *crassus* ENAY, 1966.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 097	99.2	27.4 (28)	24.4 (25)	46.6 (47)	1.12
GZN2010I 122	-	21.2	21.6	-	0.98
GZN2010I 120	-	20.8	21.5	-	0.97
GZN2010I 105	-	20.4	21.6	-	0.94
GZN2010I 141	65.2	18.4 (28)	19.9 (31)	33.2 (51)	0.92
GZN2010I 121	-	18.0	18.4	-	0.98
GZN2010I 233	-	14.3	17.5	-	0.82
GZN2010I 139	-	14.3	17.2	-	0.83
GZN2010I 139	-	11.3	15.4	-	0.73
<i>P. (Dichotomoceras) crassus</i> ENAY (1966, p. 507)	90	27 (30)	29 (32)	43 (48)	0.93
<i>P. (Dichotomoceras) crassus</i> ENAY (1966, p. 507)	75	24 (32)	27 (36)	33.5 (45)	0.89
<i>P. (Dichotomoceras) crassus</i> ENAY (1966, p. 507)	65	20 (31)	25 (38)	31 (48)	0.80

Table 40: Dimensions of *Perisphinctes* (*Dichotomoceras*) cf. *dichotomus* (BUCKMAN, 1920).

	D	Wh	Ww	U	Wh/Ww
GZN2010I 110	-	35.3	38.2	-	0.92

Plate II

Figs. 1-3: *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* (SPATH, 1931)

1: lateral view of the wholly septate specimen GZN2010I 1089 from the Dhosa Oolite of the Jara Dome (scale bar = 10 mm).

2: apertural view of the wholly septate specimen GZN2010I 1089 from the Dhosa Oolite of the Jara Dome (scale bar = 10 mm).

3: lateral view of the wholly septate specimen OUMNH JY.1160 from the southernmost tip of Khadir Island (scale bar = 10 mm).

Fig. 4: *Perisphinctes* (*Arisphinctes*) cf. *cotovuiiformis* ENAY, 2009

Lateral view of specimen GZN2010I 257, preserved with a large part of the body chamber (the cross indicates the last visible septum), from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 5 mm).

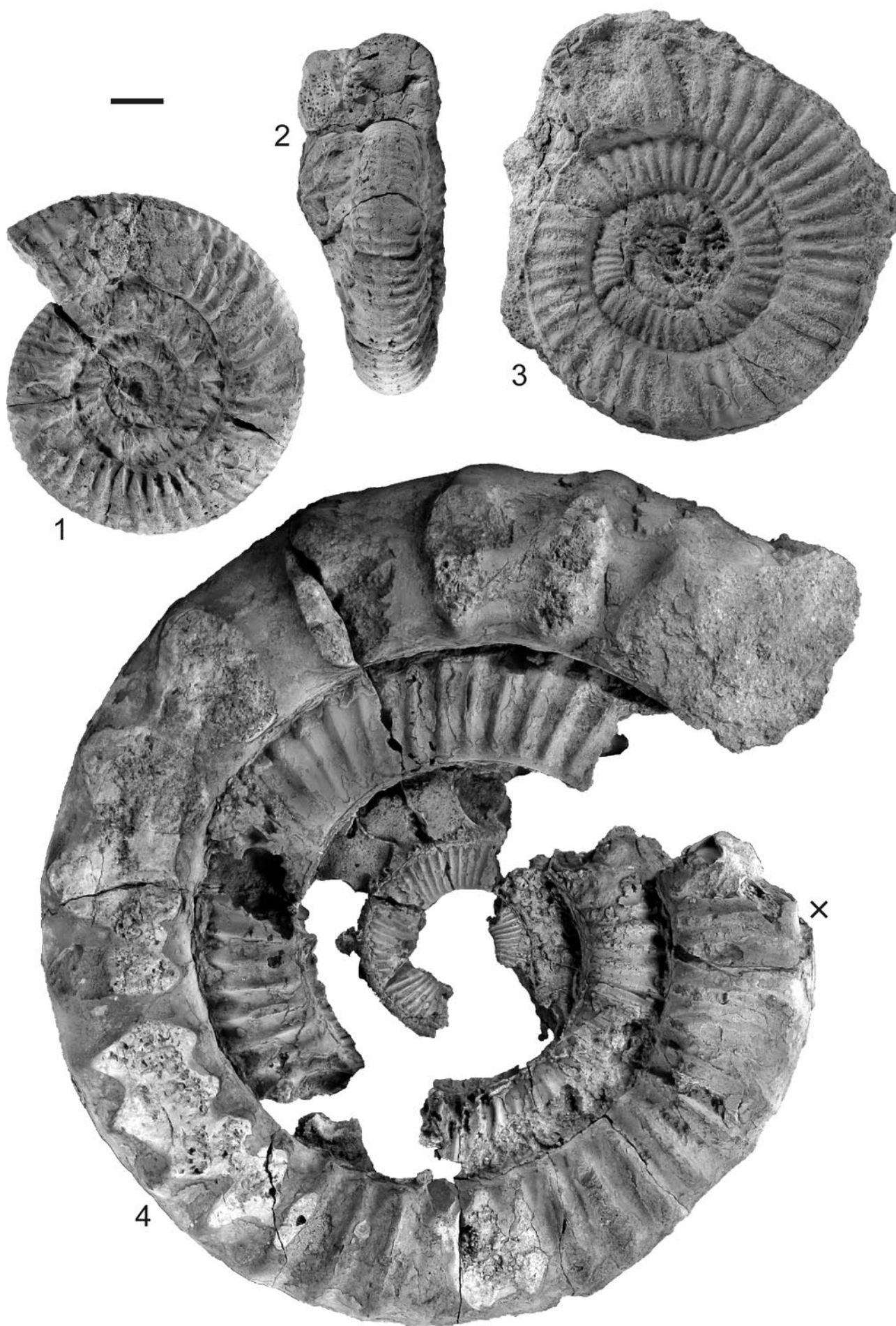


Table 41: Dimensions of *Perisphinctes* (*Dichotomoceras*) *sparsicostatus* (COLLIGNON, 1959).

	D	Wh	Ww	U	Wh/Ww
GZN2009II 073	-	22.6	24.9	-	0.91
GZN2010I 1065	-	20.2	22.0	-	0.92
GZN2009II 080	-	19.6	21.1	-	0.93
GZN2010I 1067	-	18.3	19.9	-	0.92
GZN2010I 1062	76.5	17.2 (22)	19.5 (25)	45.7 (60)	0.88
GZN2010I 1056	-	16.9	19.4	-	0.87
GZN2009II 066	-	16.7	19.3	-	0.87
GZN2010I 1066	-	15.7	16.4	-	0.96
GZN2009II 199	55.1	15.0 (27)	15.8 (29)	28.3 (51)	0.95
GZN2009II 192	-	14.8	17.7	-	0.84
GZN2010I 1003	-	14.4	16.3	-	0.88
GZN2009II 003	53.7	12.7 (24)	16.5 (31)	30.5 (57)	0.77
GZN2009II 062	48.6	13.9 (29)	14.6 (30)	25.0 (51)	0.95
GZN2009II 065	-	12.8	14.5	-	0.88
GZN2009II 002	45.4	11.5 (25)	14.3 (31)	24.6 (54)	0.80
GZN2009II 199	42.6	11.9 (28)	14.2 (33)	20.4 (48)	0.84
GZN2009II 059	42.5	11.5 (27)	13.1 (31)	22.4 (53)	0.88
GZN2009II 058	42.1	11.5 (27)	14.1 (33)	22.3 (53)	0.82
GZN2010I 1058	41.5	12.0 (29)	-	20.5 (49)	-
OUMNH JY.536	35	10 (29)	13 (37)	16 (46)	0.77
OUMNH JY.537	35	10 (29)	12 (34)	~15 (43)	0.83
GZN2009II 249	34.3	10.3 (30)	13.8 (40)	16.1 (47)	0.75
GZN2009II 064	32.8	9.5 (29)	11.3 (34)	16.9 (52)	0.84
GZN2009II 199	32.5	10.3 (32)	10.9 (34)	14.3 (44)	0.94
GZN2009II 063	-	8.5	11.5	-	0.74
OUMNH JY.531	27	8 (30)	10 (37)	13 (48)	0.80
GZN2009II 199	23.7	8.0 (34)	9.8 (41)	8.9 (38)	0.82
GZN2009II 199	17.0	7.0 (41)	8.4 (49)	4.9 (29)	0.83
GZN2009II 199	11.5	5.1 (44)	6.8 (59)	-	0.75
<i>Dichotomoceras sparsicostatum</i> COLLIGNON (1959b, pl. 66, fig. 294)	59	17 (29)	19 (32)	32 (54)	0.89

Plate III

Figs. 1-4: *Perisphinctes* (*Kranaosphinctes*) *nerunaensis* (SPATH, 1931)

1: lateral view of the wholly septate specimen OUMNH JY.348 from the Dhosa Oolite of the Jara Dome.

2: apertural view of the wholly septate specimen GZN2009II 025 from the Dhosa Conglomerate Bed of the Jara Dome.

3: lateral view of the wholly septate specimen GZN2009II 025 from the Dhosa Conglomerate Bed of the Jara Dome.

4: lateral view of the wholly septate specimen GZN2009II 164 from the Dhosa Conglomerate Bed close to Medisar, Jhura Dome.

Figs. 5, 6: *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875

5: lateral view of the wholly septate specimen OUMNH JY.1168 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift.

6: ventral view of the wholly septate specimen OUMNH JY.1168 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift.



10 mm

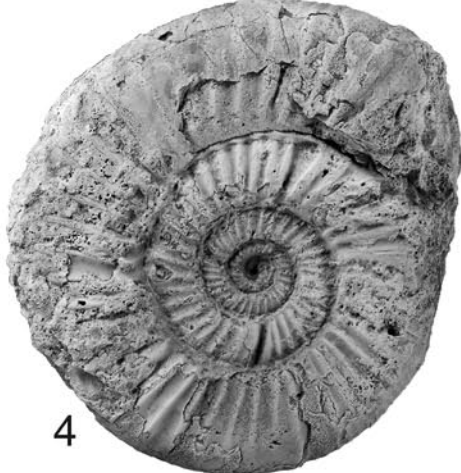


Table 42: Dimensions of *Perisphinctes* (*Dichotomoceras*) *stenocycloides* SIEMIRADZKI, 1898.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 258	122.2	32.0 (26)	27.2 (22)	61.0 (50)	1.18
GZN2010I 182	119.2	31.6 (27)	27.5 (23)	61.2 (51)	1.15
GZN2010I 140	102.5	29.1 (28)	27.3 (27)	51.0 (50)	1.07
GZN2010I 135	96.7	27.4 (28)	25.2 (26)	48.5 (50)	1.09
GZN2010I 102	-	20.5	18.8	-	1.09
<i>P. (Dichotomoceras) stenocycloides</i> (SIEMIRADZKI) (GYGI, 2000, p. 85)	92	28 (30)	26 (28)	44 (48)	1.07
<i>Dichotomosphinctes stenocycloides</i> SIEMIRADZKI (COLLIGNON, 1959b, pl. 65, fig. 291)	89	28 (31)	20 (22)	40 (45)	1.40
<i>Dichotomosphinctes falculae</i> (RONCHANDÉ) (SPATH, 1931a, p. 435)	63	21 (33)	19 (30)	26 (41)	1.11
<i>P. (Dichotomosphinctes) luciae</i> DE RIAZ (ENAY & BOULLIER, 1981, pl. 2, fig. 4)	107	32 (30)	-	53 (50)	-
<i>P. (Dichotomosphinctes) luciae</i> DE RIAZ (ENAY, 1966, p. 494)	98	30 (31)	25 (26)	43 (44)	1.20
<i>P. (Dichotomosphinctes) luciae</i> DE RIAZ (ENAY, 1966, p. 494)	68	23 (34)	22 (32)	29 (43)	1.05
<i>P. virguloides</i> WAAGEN (1875c p. 204)	118	34 (29)	28 (24)	49 (42)	1.21
<i>P. virguloides</i> WAAGEN (1875c, p. 204)	42	14 (33)	14 (33)	17 (40)	1.00
<i>P. (Dichotomosphinctes) buckmani</i> ARKELL (1938, p. 79)	115	33 (29)	32 (28)	56 (49)	1.03
<i>P. (Dichotomosphinctes) buckmani</i> ARKELL (ENAY, 1966, p. 478)	95	27 (28)	22.5 (24)	48 (51)	1.20

Table 43: Dimensions of *Perisphinctes* (*Dichotomoceras*) cf. *stenocycloides* SIEMIRADZKI, 1898.

	D	Wh	Ww	U	Wh/Ww
GZN2010I 116	-	33.2	28.7	-	1.16

Plate IV

Figs. 1-6: *Perisphinctes* (*Kranaosphinctes*) *pagri* WAAGEN, 1875

- 1: lateral view of the wholly septate specimen GZN2010I 081 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
- 2: ventral view of the wholly septate specimen GZN2010I 090 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
- 3: lateral view of the wholly septate specimen GZN2010I 119 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).
- 4: lateral view of the wholly septate specimen GZN2010I 096 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
- 5: lateral view of the wholly septate specimen GZN2010I 090 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
- 6: ventral view of the wholly septate specimen GZN2010I 096 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 16.5 mm).

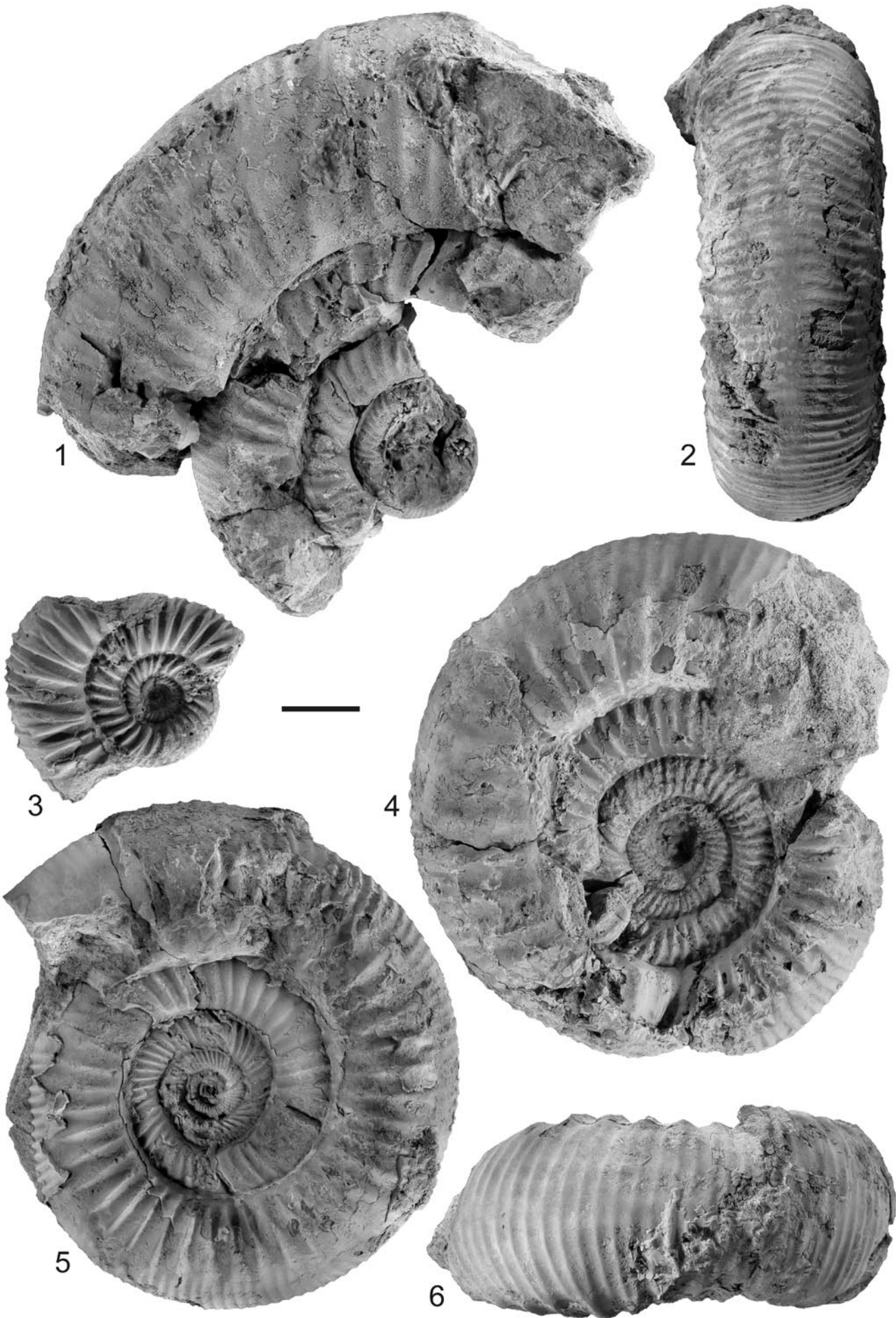


Plate V

Figs. 1-11: *Perisphinctes* (*Kranaosphinctes*) *subevolutus* WAAGEN, 1875

- 1: lateral view of the wholly septate specimen GZN2010I 1030 from the Dhosa Conglomerate Bed at Ler, southeast of Bhuj (scale bar = 15 mm).
- 2: lateral view of the wholly septate specimen GZN2010I 067 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
- 3: ventral view of the wholly septate specimen GZN2009II 208 from the Dhosa Conglomerate Bed of the Jumara Dome (scale bar = 15 mm).
- 4: lateral view of the wholly septate specimen GZN2009II 234 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 15 mm).
- 5: lateral view of the wholly septate specimen GZN2010I 237 from the Trama River, Wagad Uplift (scale bar = 15 mm).
- 6: lateral view of the wholly septate specimen GZN2009II 208 from the Dhosa Conglomerate Bed of the Jumara Dome (scale bar = 15 mm).
- 7: whorl section of the wholly septate specimen GZN2009II 208 from the Dhosa Conglomerate Bed of the Jumara Dome (scale bar = 15 mm).
- 8: lateral view of the wholly septate specimen GZN2010I 203 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 15 mm).
- 9: lateral view of the wholly septate specimen GZN2009II 014 from the Dhosa Conglomerate Bed of the Jumara Dome (scale bar = 10 mm).
- 10: lateral view of the wholly septate specimen GZN2009II 012 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 15 mm).
- 11: apertural view of the wholly septate specimen GZN2009II 012 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 15 mm).

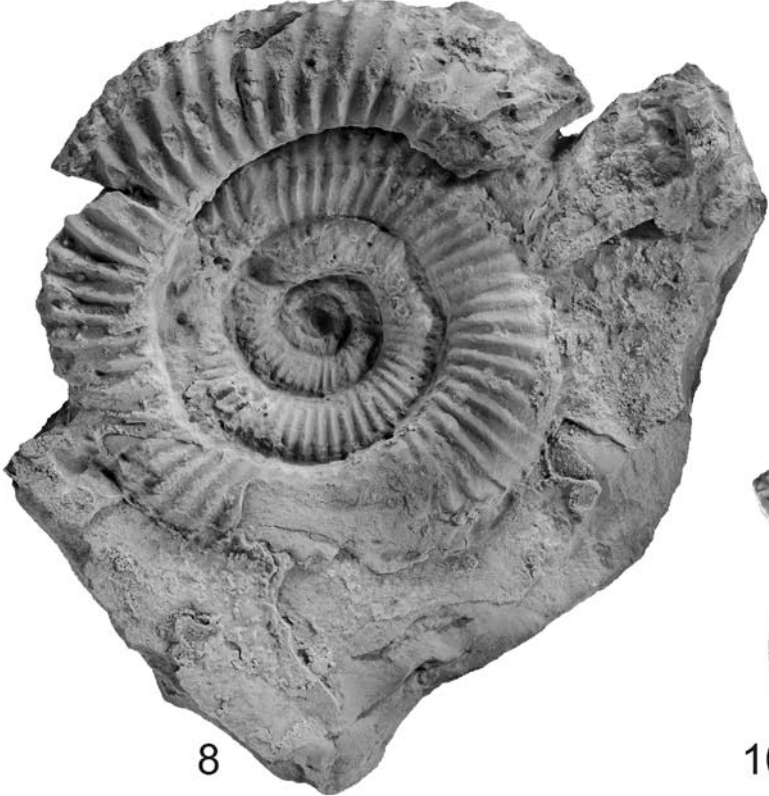
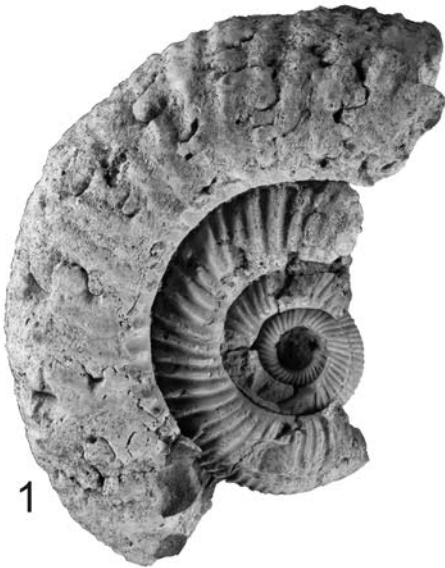


Plate VI

Figs. 1-3: *Perisphinctes* (*Arisphinctes*) sp. cf. *Perisphinctes calvus* (J. DE C. SOWERBY, 1840)

1: lateral view of the wholly septate specimen GZN2010I 106 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).

2: lateral view of the wholly septate specimen GZN2010I 127 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 12.5 mm).

3: ventral view of the wholly septate specimen GZN2010I 106 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).

Figs. 4, 6: *Perisphinctes* (*Arisphinctes*) cf. *colei* SPATH, 1931

4: lateral view of the wholly septate specimen GZN2009II 027 from a thin layer of Dhosa Oolite on top of the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome (scale bar = 10 mm).

6: lateral view of the wholly septate specimen GZN2009II 191 from the Dhosa Oolite of the Jumara Dome (scale bar = 10 mm).

Fig. 5: *Perisphinctes* (*Dichotomosphinctes*) sp.

Lateral view of specimen GZN2010I 1090, preserved with a part of the body chamber (the cross indicates the last visible septum), from the Dhosa Oolite of the Jara Dome (scale bar = 10 mm).

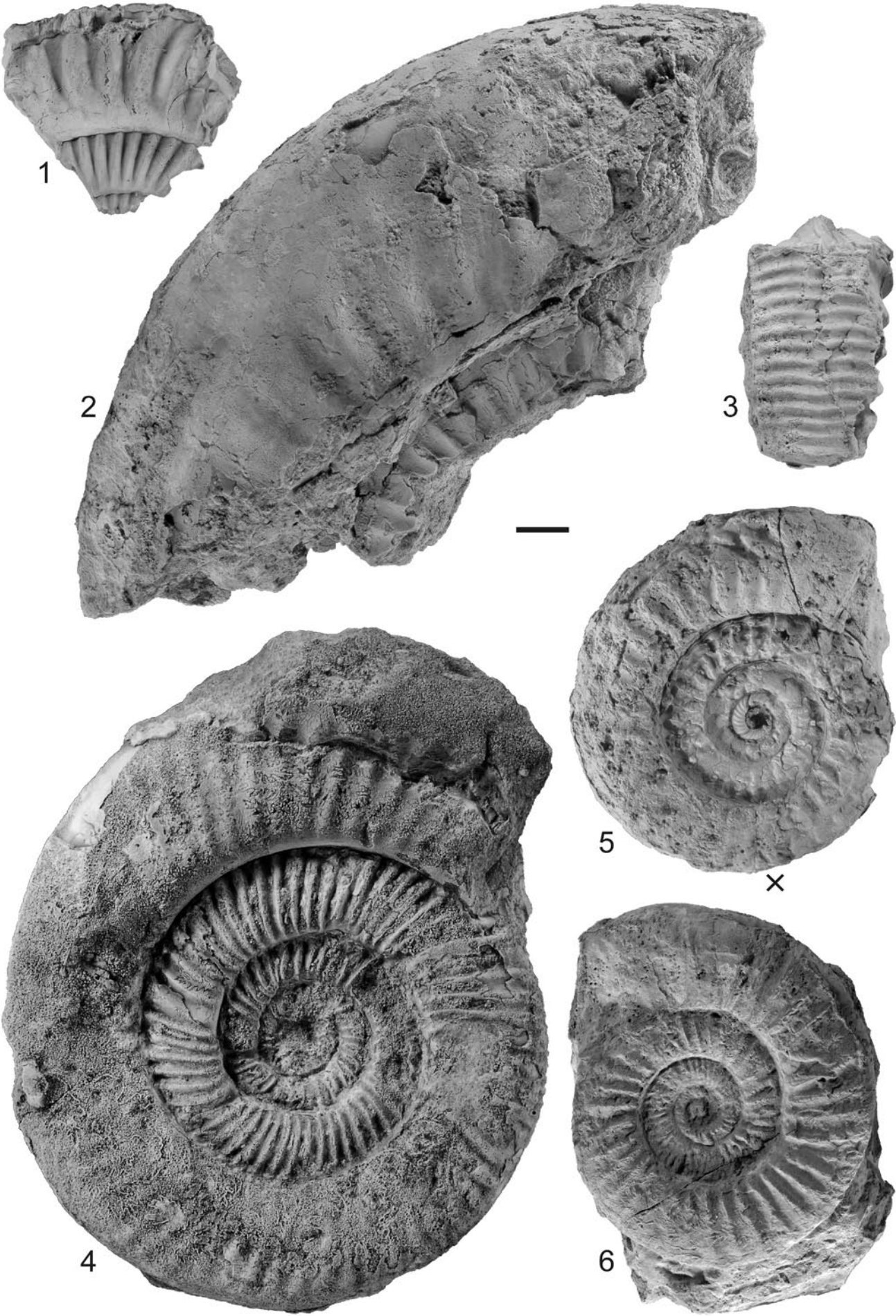


Plate VII

Figs. 1, 2: *Perisphinctes (Arisphinctes) aff. cotovuiiformis* ENAY, 2009

1: lateral view of the wholly septate specimen GZN2009II 207 from the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome.

2: ventral view of the wholly septate specimen GZN2009II 207 from the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome.

Figs. 3-7 *Perisphinctes (Arisphinctes) chloroolithicus* (GÜMBEL, 1865)

3: lateral view of the wholly septate specimen GZN2010I 213 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.

4: lateral view of the wholly septate specimen GZN2010I 185 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.

5: lateral view of the wholly septate specimen GZN2010I 157 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.

6: lateral view of the wholly septate specimen GZN2010I 183 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.

7: ventral view of the wholly septate specimen GZN2010I 213 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.

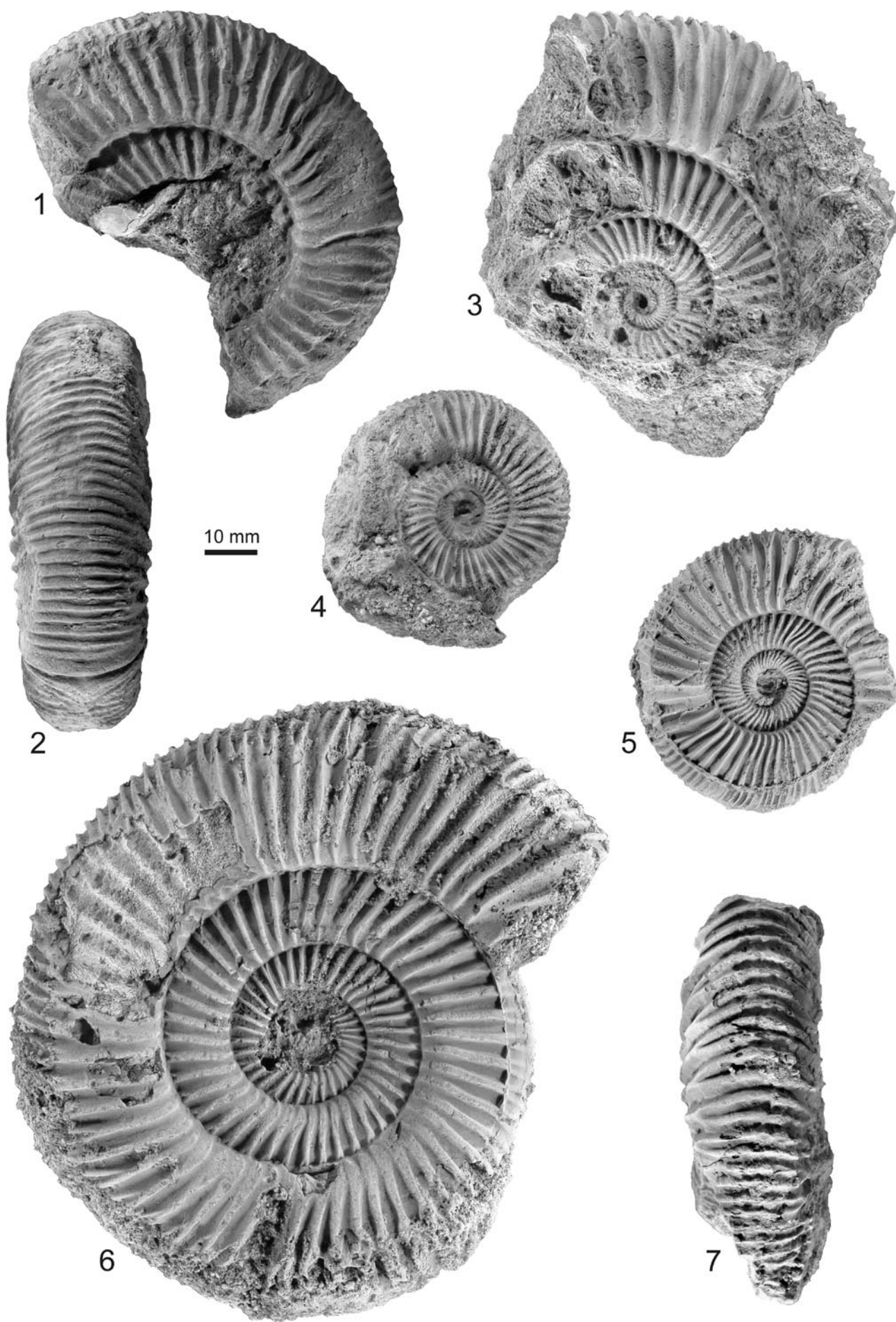


Plate VIII

- Fig. 1: *Perisphinctes* (*Dichotomosphinctes*) aff. *lehmani* (COLLIGNON, 1959)
Lateral view of specimen GZN2010I 144, preserved with a part of the body chamber (the cross indicates the last visible septum), from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift (scale bar = 10 mm).
- Figs. 2-5: *Perisphinctes* (*Arisphinctes*) *polymorphus* (SPATH, 1931)
2: lateral view of specimen GZN2009II 018, juvenile with almost the entire body chamber (the cross indicates the last visible septum), from the Dhosa Oolite of the Jara Dome (scale bar = 10 mm).
3: ventral view of specimen GZN2009II 018 from the Dhosa Oolite of the Jara Dome (scale bar = 10 mm).
4: lateral view of the wholly septate specimen GZN2009II 017 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 10 mm).
5: lateral view of the wholly septate specimen GZN2009II 016 from the Dhosa Conglomerate Bed of the Jumara Dome (scale bar = 10 mm).
- Figs. 6, 7: *Perisphinctes* (*Arisphinctes*) *kantkotensis* sp. nov.
6: lateral view of the wholly septate specimen GZN2011I 347 (holotype) from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 20 mm).
7: apertural view of the wholly septate specimen GZN2011I 347 (holotype) from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 20 mm).

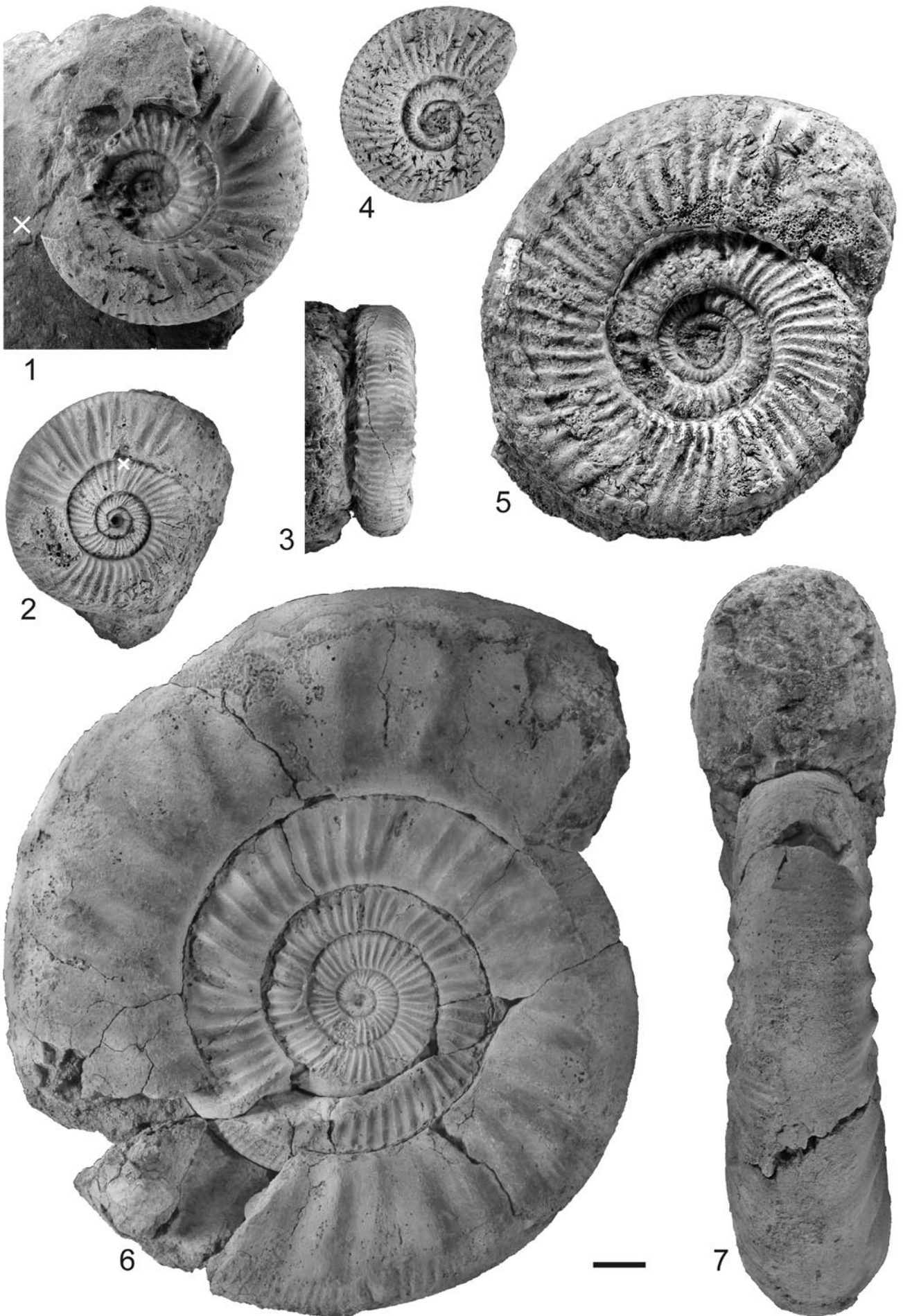


Plate IX

Figs. 1-7: *Perisphinctes* (*Arisphinctes*) *kheraensis* SPATH, 1931

- 1: lateral view of the wholly septate specimen GZN2009II 195 from the Dhosa Oolite of the Jara Dome.
- 2: lateral view of the wholly septate specimen GZN2009II 163 from a reworked, concretionary slab floating in the Dhosa Conglomerate Bed of the Jara Dome.
- 3: lateral view of the wholly septate specimen GZN2010I 1014 from the Dhosa Conglomerate Bed south of Lodai, Habo Dome.
- 4: ventral view of the wholly septate specimen GZN2010I 1014 from the Dhosa Conglomerate Bed south of Lodai, Habo Dome.
- 5: lateral view of the wholly septate specimen GZN2009II 060 from the Dhosa Oolite of the Jara Dome.
- 6: apertural view of the wholly septate specimen GZN2009II 011 from the Dhosa Conglomerate Bed of the Jara Dome.
- 7: lateral view of the wholly septate specimen GZN2009II 011 from the Dhosa Conglomerate Bed of the Jara Dome.



10 mm



Plate X

Figs. 1-8: *Perisphinctes (Liosphinctes) plicatilis* (J. SOWERBY, 1817)

- 1: lateral view of the wholly septate specimen GZN2010I 245 from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift.
- 2: lateral view of the wholly septate specimen GZN2010I 193 from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift.
- 3: lateral view of the wholly septate specimen GZN2010I 261 with unknown locality.
- 4: lateral view of the wholly septate specimen GZN2010I 178 from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift.
- 5: ventral view of the wholly septate specimen GZN2010I 245 from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift.
- 6: lateral view of the wholly septate specimen GZN2010I 165 from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift.
- 7: ventral view of the wholly septate specimen GZN2010I 261 with unknown locality.
- 8: ventral view of the wholly septate specimen GZN2010I 193 from the Kantkote Ammonite Beds in the Tramau River, Wagad Uplift.

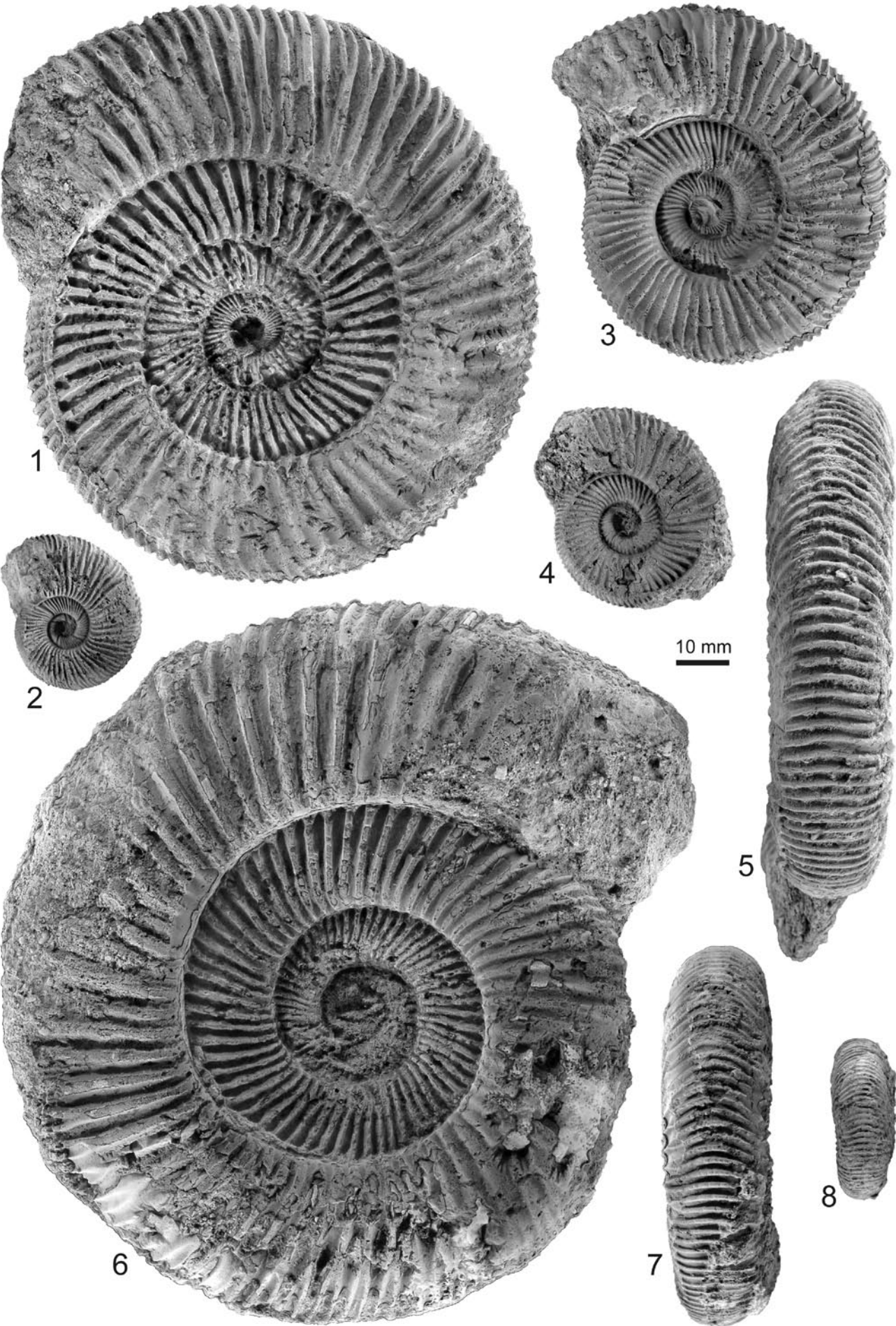


Plate XI

- Figs. 1, 2: *Perisphinctes* sp. cf. *Perisphinctes* (*Dichotomosphinctes*) *antecedens* SALFELD, 1914
1: lateral view of the wholly septate specimen GZN2009II 194 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 10 mm).
2: lateral view of the wholly septate specimen GZN2009II 013 from the Dhosa Conglomerate Bed close to Medisar, Jhura Dome (scale bar = 10 mm).
- Figs. 3, 4: *Perisphinctes* (*Arisphinctes*) cf. *subcolubrinus* WAAGEN, 1875
3: lateral view of the wholly septate specimen GZN2010I 064 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).
4: ventral view of the wholly septate specimen GZN2010I 064 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).
- Figs. 5, 6: *Perisphinctes* (*Arisphinctes*) *kachchensis* sp. nov.
5: apertural view of the wholly septate specimen GZN2010I 091 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 14 mm).
6: lateral view of the wholly septate specimen GZN2010I 091 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 14 mm).

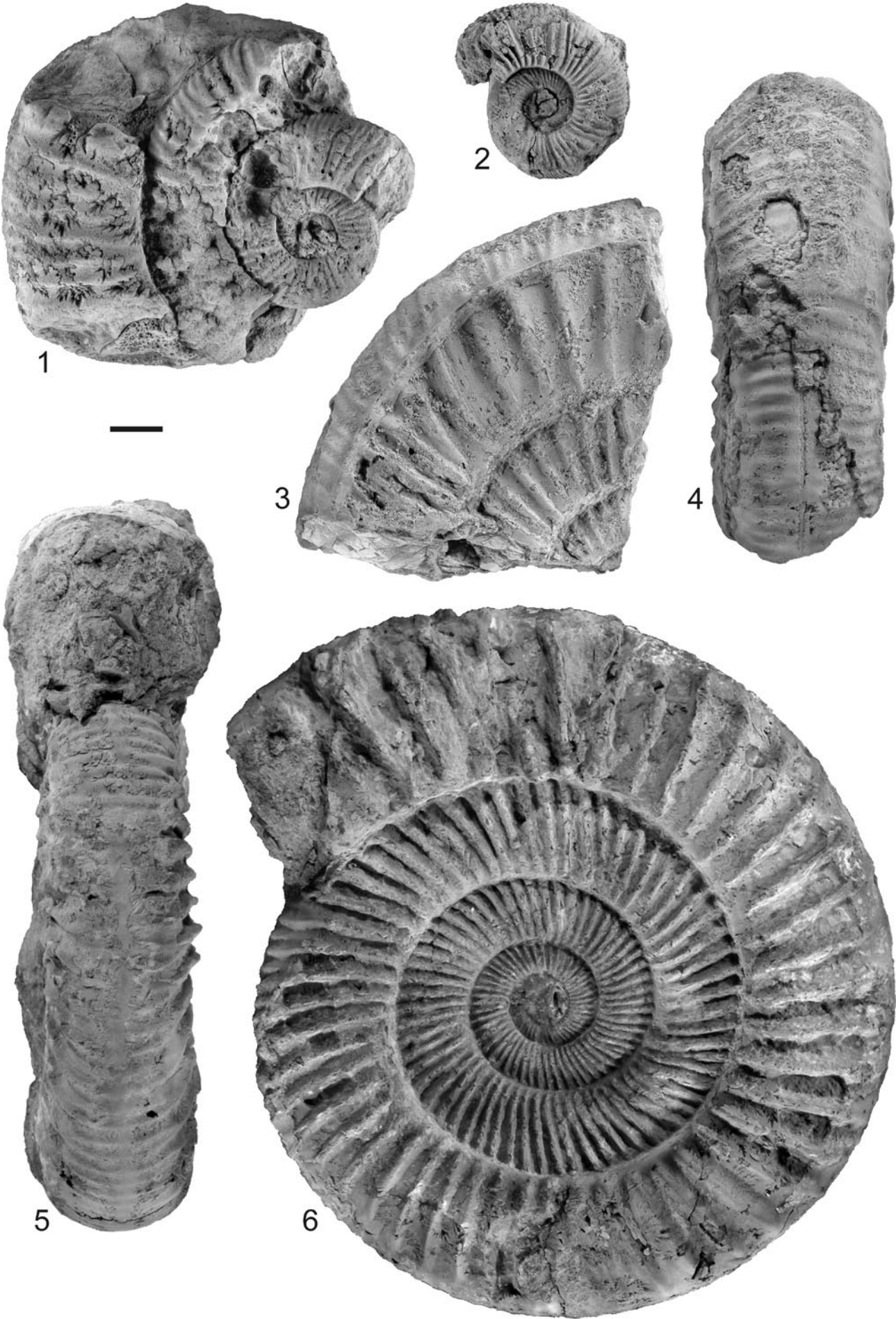


 Plate XII

- Figs. 1-3: *Perisphinctes* (*Dichotomosphinctes*) *elisabethae* DE RIAZ, 1898
 1: ventral view of specimen GZN2010I 094 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift.
 2: lateral view of specimen GZN2010I 094, preserved with a part of the body chamber (the cross indicates the last visible septum), from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift.
 3: lateral view of specimen GZN2010I 137 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift. No suture line is visible in the outer whorl.
- Figs. 4, 5: *Perisphinctes* (*Dichotomosphinctes*) aff. *gamelai* ARKELL, 1947
 4: lateral view of specimen GZN2010I 109 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift. No suture line is visible in the outer whorl.
 5: apertural view of specimen GZN2010I 109 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift. No suture line is visible in the outer whorl.
- Figs. 6, 7: *Perisphinctes* (*Arisphinctes*) cf. *trifidus* (J. SOWERBY, 1821)
 6: lateral view of the wholly septate specimen GZN2010I 1082 from the Dhosa Conglomerate Bed of the Jara Dome.
 7: lateral view of specimen GZN2009II 114, juvenile with almost the entire body chamber (the cross indicates the last visible septum), from a thin layer of Dhosa Oolite on top of the Dhosa Conglomerate Bed at Rudra Mata, Habo Dome.
- Figs. 8-13: *Perisphinctes* (*Dichotomosphinctes*) *jacki* (SPATH, 1931)
 8: lateral view of the wholly septate specimen GZN2009II 074 from the Dhosa Oolite of the Jumara Dome.
 9: apertural view of the wholly septate specimen OUMNH JY.273 from the Dhosa Oolite of the Jara Dome.
 10: apertural view of the wholly septate specimen GZN2009II 005 from the Dhosa Conglomerate Bed of the Jara Dome.
 11: lateral view of the wholly septate specimen OUMNH JY.273 from the Dhosa Oolite of the Jara Dome.
 12: lateral view of the wholly septate specimen GZN2009II 024 from the Dhosa Conglomerate Bed of the Jara Dome.
 13: lateral view of the wholly septate specimen GZN2009II 005 from the Dhosa Conglomerate Bed of the Jara Dome.

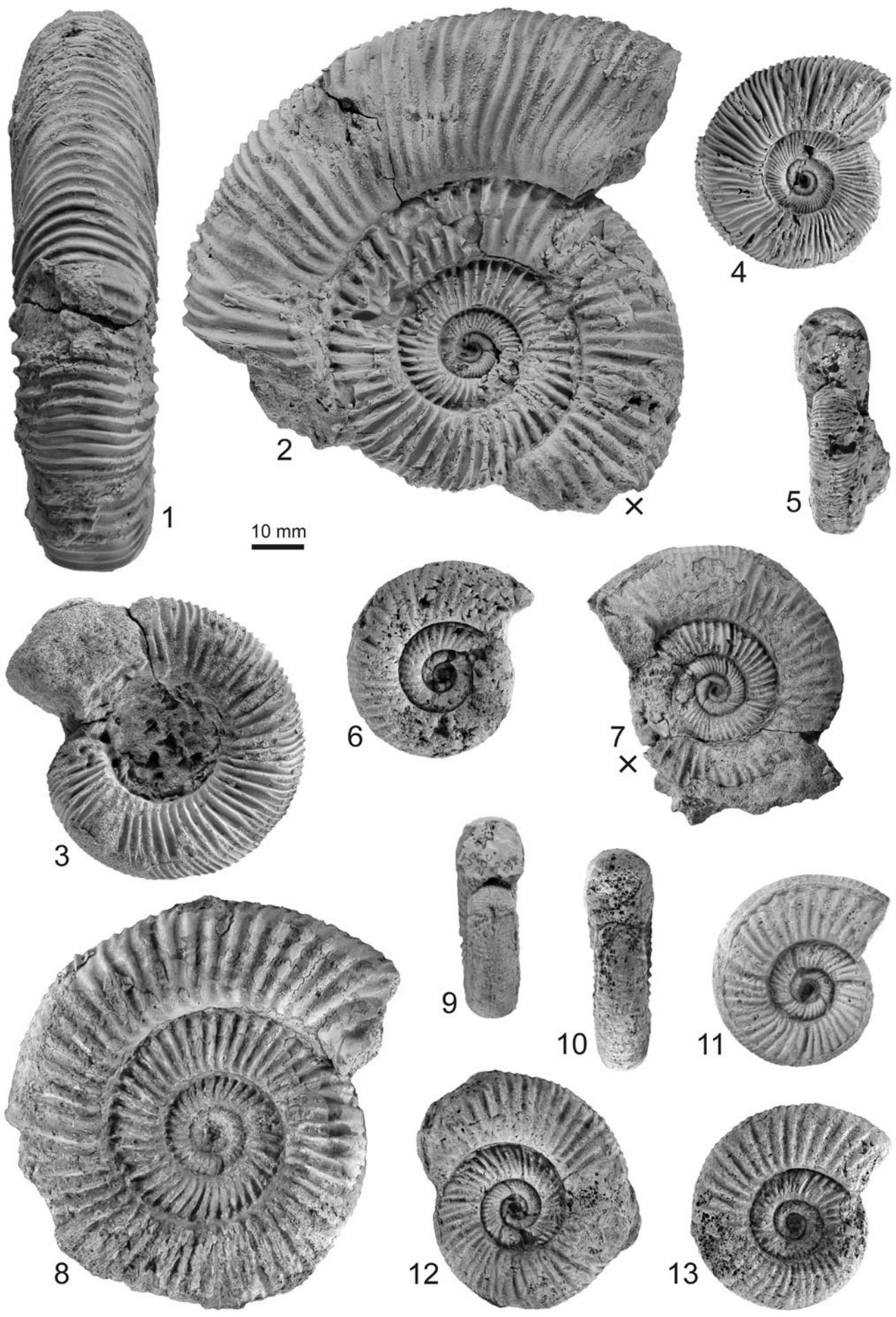


Plate XIII

Figs. 1-4, 6: *Perisphinctes* (*Dichotomosphinctes*) cf. *obliqueplicatus* WAAGEN, 1875

- 1: lateral view of the wholly septate specimen GZN2009II 189 from the Dhosa Conglomerate Bed close to Kamaguna, Jhura Dome.
- 2: ventral view of the wholly septate specimen GZN2009II 189 from the Dhosa Conglomerate Bed close to Kamaguna, Jhura Dome.
- 3: ventral view of the wholly septate specimen GZN2009II 202 from the Dhosa Conglomerate Bed of the Jara Dome.
- 4: lateral view of the wholly septate specimen OUMNH JY.1159 from the southernmost tip of Khadir Island.
- 6: lateral view of the wholly septate specimen GZN2009II 202 from the Dhosa Conglomerate Bed of the Jara Dome.

Figs. 5, 7-9: *Perisphinctes* (*Arisphinctes*) *rota* WAAGEN, 1875

- 5: lateral view of specimen GZN2009II 227 from the Dhosa Conglomerate Bed close to Kamaguna, Jhura Dome. No suture line is visible in the outer whorl.
- 7: ventral view of specimen GZN2009II 227 from the Dhosa Conglomerate Bed close to Kamaguna, Jhura Dome. No suture line is visible in the outer whorl.
- 8: lateral view of the wholly septate specimen OUMNH JY.925 from the Dhosa Oolite close to Kamaguna, Jhura Dome.
- 9: apertural view of the wholly septate specimen OUMNH JY.925 from the Dhosa Oolite close to Kamaguna, Jhura Dome.

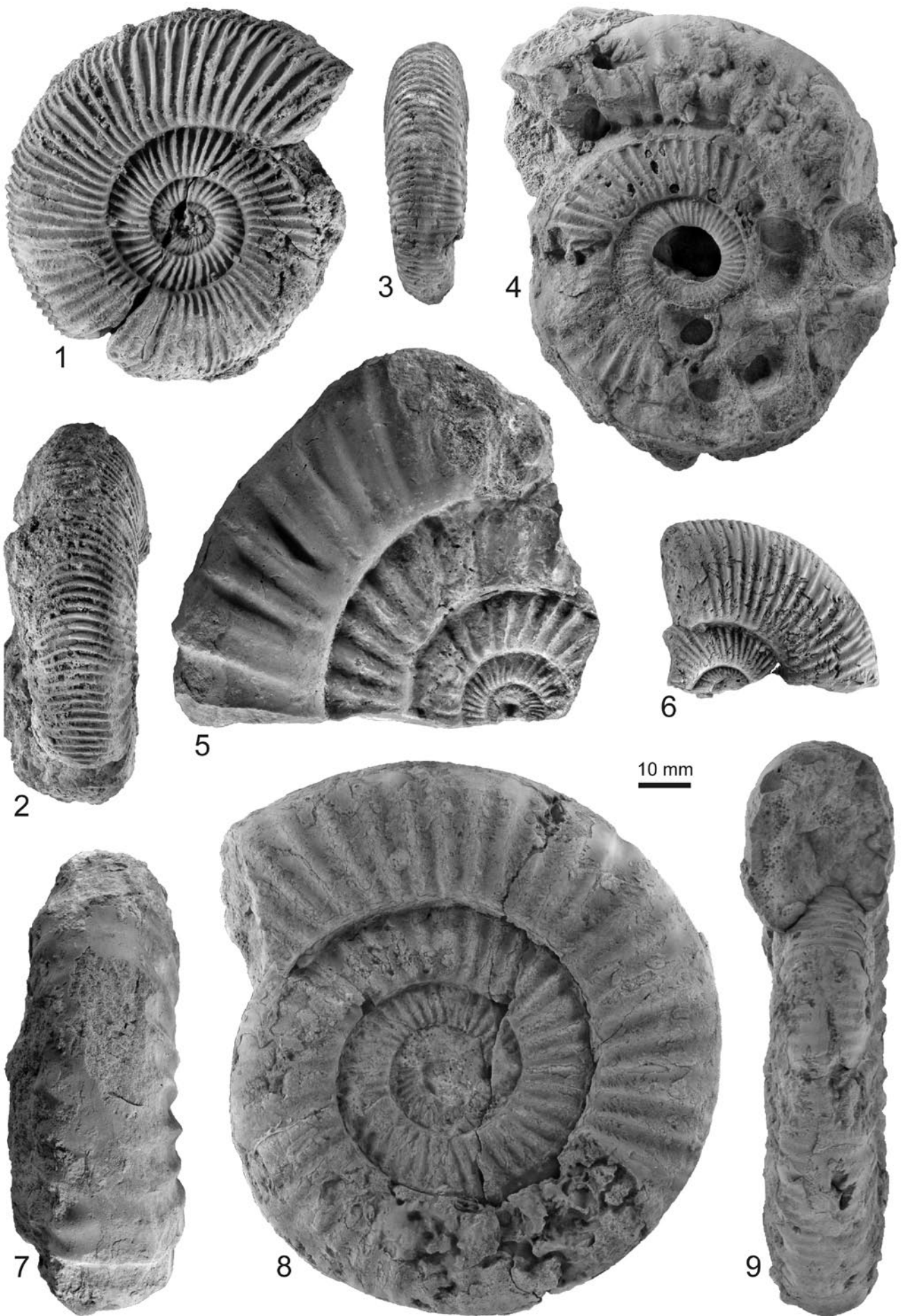


Plate XIV

- Fig. 1: *Perisphinctes (Dichotomoceras) cf. virguloides* WAAGEN, 1875
Lateral view of the wholly septate specimen GZN2010I 108 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift.
- Fig. 2: *Perisphinctes (Dichotomosphinctes) rotiformis* (SPATH, 1931)
Lateral view of specimen GZN2009II 067 from the Dhosa Oolite of the Jara Dome. No suture line is visible in the outer whorl.
- Figs. 3-5: *Perisphinctes* sp. cf. *Perisphinctes (Dichotomosphinctes) wartae* BUKOWSKI, 1887
3: lateral view of the wholly septate specimen GZN2010I 1077 from the Dhosa Conglomerate Bed of the Jara Dome.
4: lateral view of the wholly septate specimen GZN2009II 237 from the Dhosa Conglomerate Bed of the Jara Dome.
5: ventral view of the wholly septate specimen GZN2010I 1077 from the Dhosa Conglomerate Bed of the Jara Dome.
- Figs. 6, 7: *Perisphinctes (Dichotomosphinctes) aff. wartae* BUKOWSKI, 1887
6: lateral view of specimen OUMNH JY.1166 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift. No suture line is visible in the outer whorl.
7: ventral view of specimen OUMNH JY.1166 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift. No suture line is visible in the outer whorl.
- Figs. 8, 9: *Perisphinctes (Dichotomosphinctes) subhelenae* (SPATH, 1931)
8: ventral view of the wholly septate specimen GZN2010I 184 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.
9: lateral view of the wholly septate specimen GZN2010I 184 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.

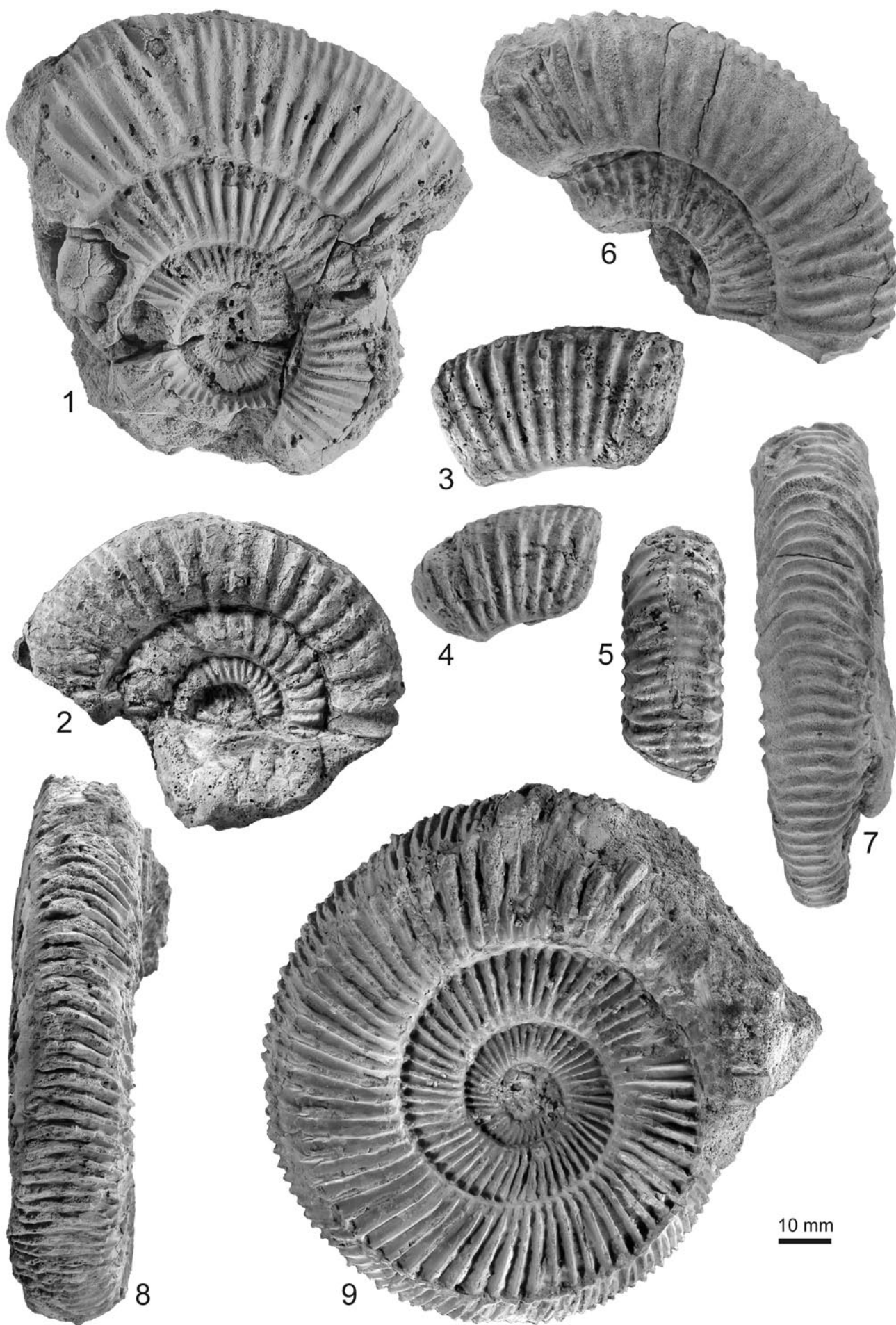


 Plate XV

- Figs. 1-3: *Perisphinctes (Dichotomoceras) cf. besairiei* (COLLIGNON, 1959)
 1: lateral view of specimen OUMNH JY.1169 from the Patasar Shale member above the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm). No suture line is visible in the outer whorl.
 2: lateral view of specimen OUMNH JY.1169 from the Patasar Shale member above the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm). No suture line is visible in the outer whorl.
 3: ventral view of specimen OUMNH JY.1169 from the Patasar Shale member above the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm). No suture line is visible in the outer whorl.
- Figs. 4-6: *Perisphinctes (Dichotomosphinctes) aff. aeneas* GEMMELLARO, 1872
 4: lateral view of the wholly septate specimen GZN2010I 219 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 15 mm).
 5: ventral view of the wholly septate specimen GZN2010I 219 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 15 mm).
 6: lateral view of specimen GZN2010I 169 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 15 mm). No suture line is visible in the outer whorl.
- Fig. 7: *Perisphinctes (Dichotomosphinctes) cf. tizianiformis* CHOFFAT, 1893
 Lateral view of the wholly septate specimen GZN2009II 206 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 15 mm).
- Figs. 8-10: *Perisphinctes* sp. cf. *Perisphinctes (Dichotomoceras) bifurcatoides* ENAY, 1966
 8: lateral view of the wholly septate specimen GZN2010I 117 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
 9: lateral view of the wholly septate specimen GZN2010I 124 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
 10: ventral view of the wholly septate specimen GZN2010I 117 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 15 mm).
- Figs. 11-13: *Perisphinctes (Dichotomosphinctes) tizianiformis* CHOFFAT, 1893
 11: lateral view of specimen GZN2010I 149, adult with the aperture (the cross indicates the last visible septum), from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 15 mm).
 12: detail of the aperture of specimen GZN2010I 149 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm).
 13: ventral view of specimen GZN2010I 149 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 15 mm).

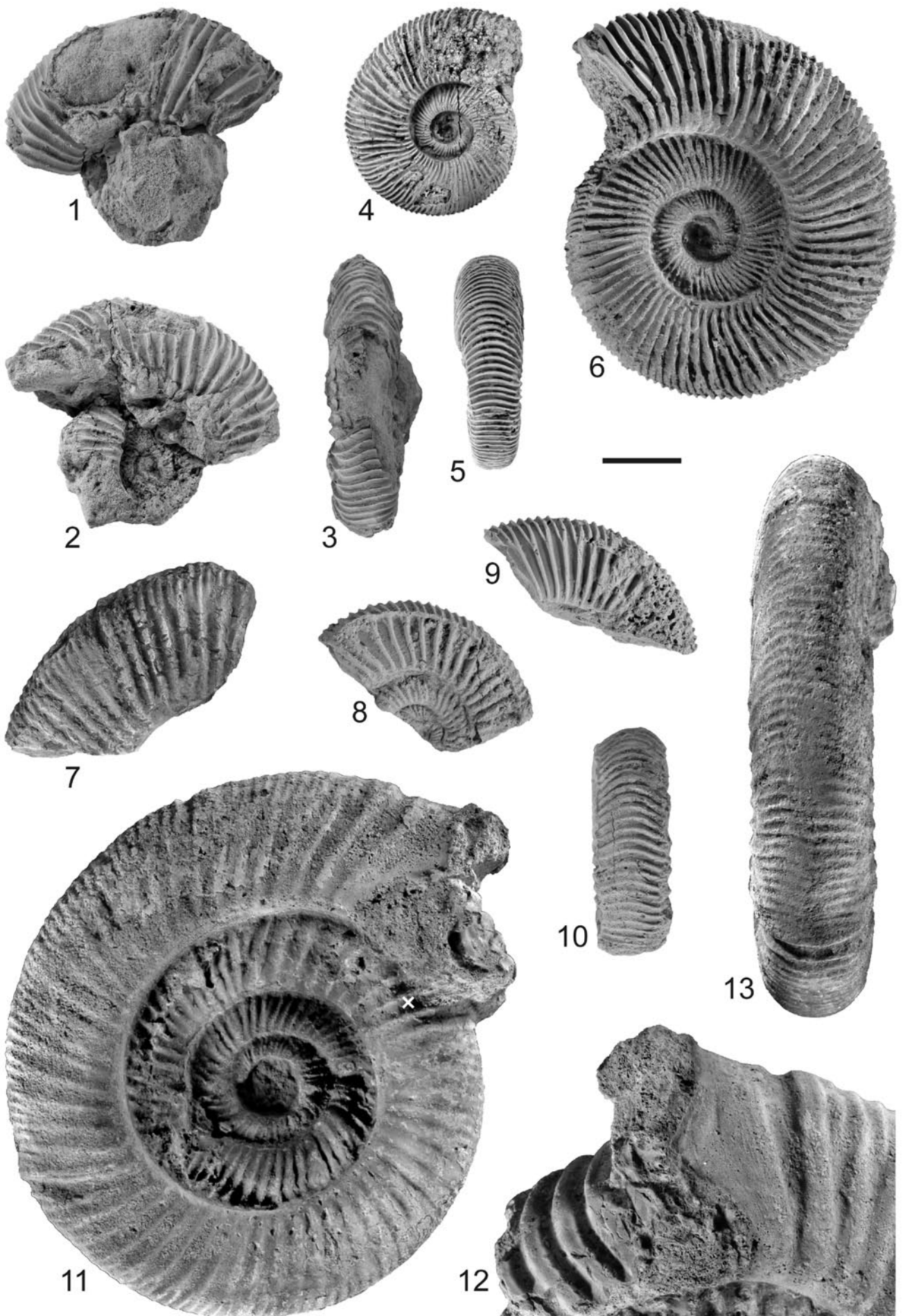


Plate XVI

- Figs. 1, 2: *Perisphinctes (Dichotomoceras)* cf. *dichotomus* (BUCKMAN, 1920)
1: ventral view of specimen GZN2010I 110 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm). No suture line is visible in the outer whorl.
2: lateral view of specimen GZN2010I 110 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm). No suture line is visible in the outer whorl.
- Figs. 3-5: *Perisphinctes (Dichotomoceras)* cf. *bifurcatus* (QUENSTEDT, 1847)
3: lateral view of the wholly septate specimen GZN2010I 123 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 5 mm).
4: ventral view of the wholly septate specimen GZN2010I 118 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 5 mm).
5: lateral view of the wholly septate specimen GZN2010I 118 from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 5 mm).
- Figs. 6-8: *Perisphinctes (Dichotomoceras)* gr. *crassus* ENAY, 1966
6: ventral view of specimen GZN2010I 233 from the Trama River, Wagad Uplift (scale bar = 10 mm). No suture line is visible in the outer whorl.
7: lateral view of specimen GZN2010I 141 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift (scale bar = 10 mm). No suture line is visible in the outer whorl.
8: lateral view of specimen GZN2010I 097, preserved with a part of the body chamber (the cross indicates the last visible septum), from the Kantkote Ammonite Beds southwest of Kantkote Village, Wagad Uplift (scale bar = 10 mm).

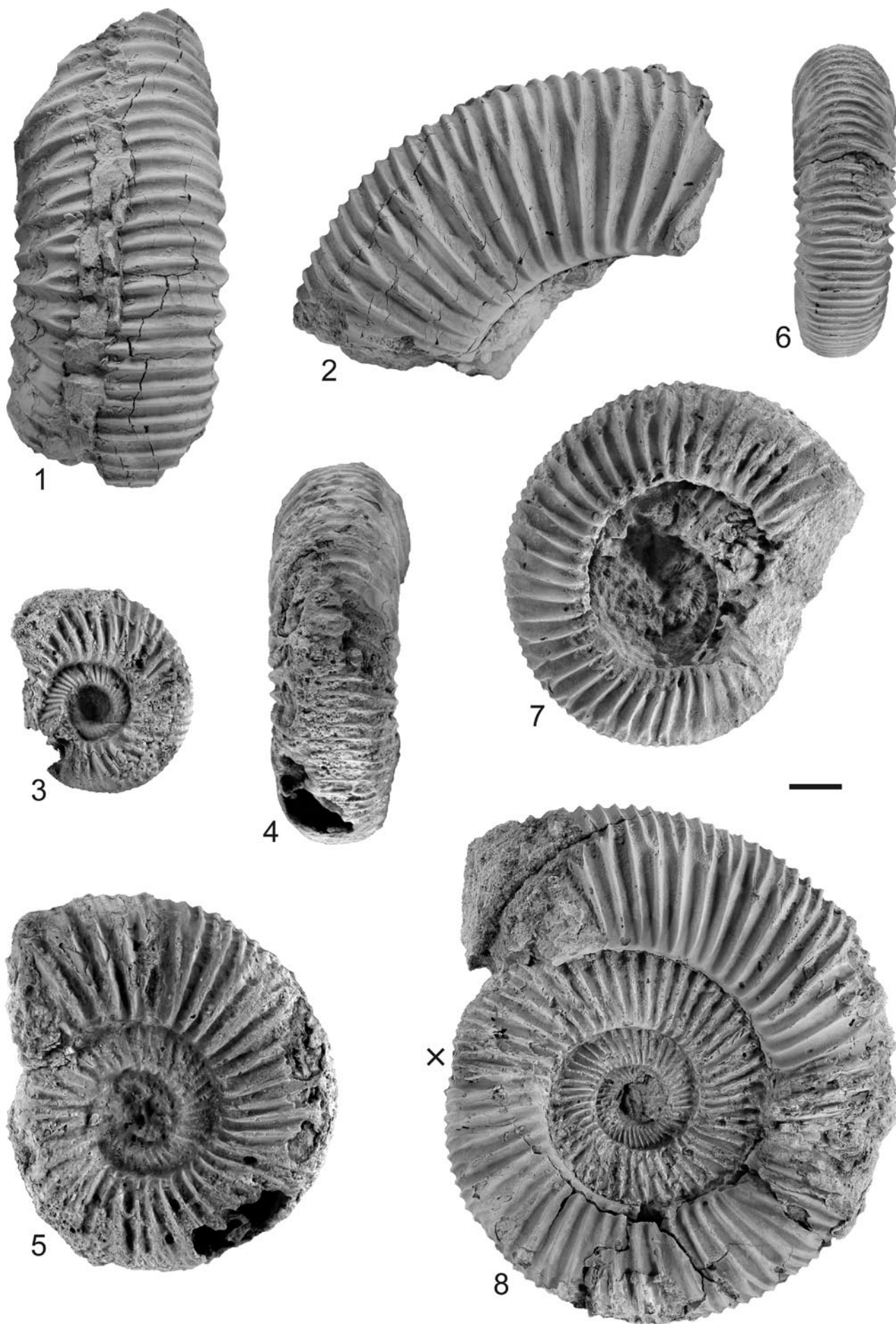


Plate XVII

Figs. 1-9: *Perisphinctes (Dichotomoceras) sparsicostatus* (COLLIGNON, 1959)

- 1: ventral view of the wholly septate specimen GZN2009II 073 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 15 mm).
- 2: lateral view of the wholly septate specimen GZN2009II 073 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 15 mm).
- 3: lateral view of the wholly septate specimen GZN2009II 249 from the Dhosa Oolite at Ler, southeast of Bhuj (scale bar = 10 mm).
- 4: ventral view of the wholly septate specimen GZN2009II 249 from the Dhosa Oolite at Ler, southeast of Bhuj (scale bar = 10 mm).
- 5: lateral view of the wholly septate specimen GZN2010I 1062 from the Dhosa Conglomerate Bed of the Jumara Dome (scale bar = 15 mm).
- 6: lateral view of the wholly septate specimen GZN2009II 059 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 10 mm).
- 7: ventral view of the wholly septate specimen GZN2009II 058 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 10 mm).
- 8: lateral view of the wholly septate specimen GZN2009II 058 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 10 mm).
- 9: lateral view of the wholly septate specimen GZN2009II 003 from the Dhosa Conglomerate Bed of the Jara Dome (scale bar = 10 mm).

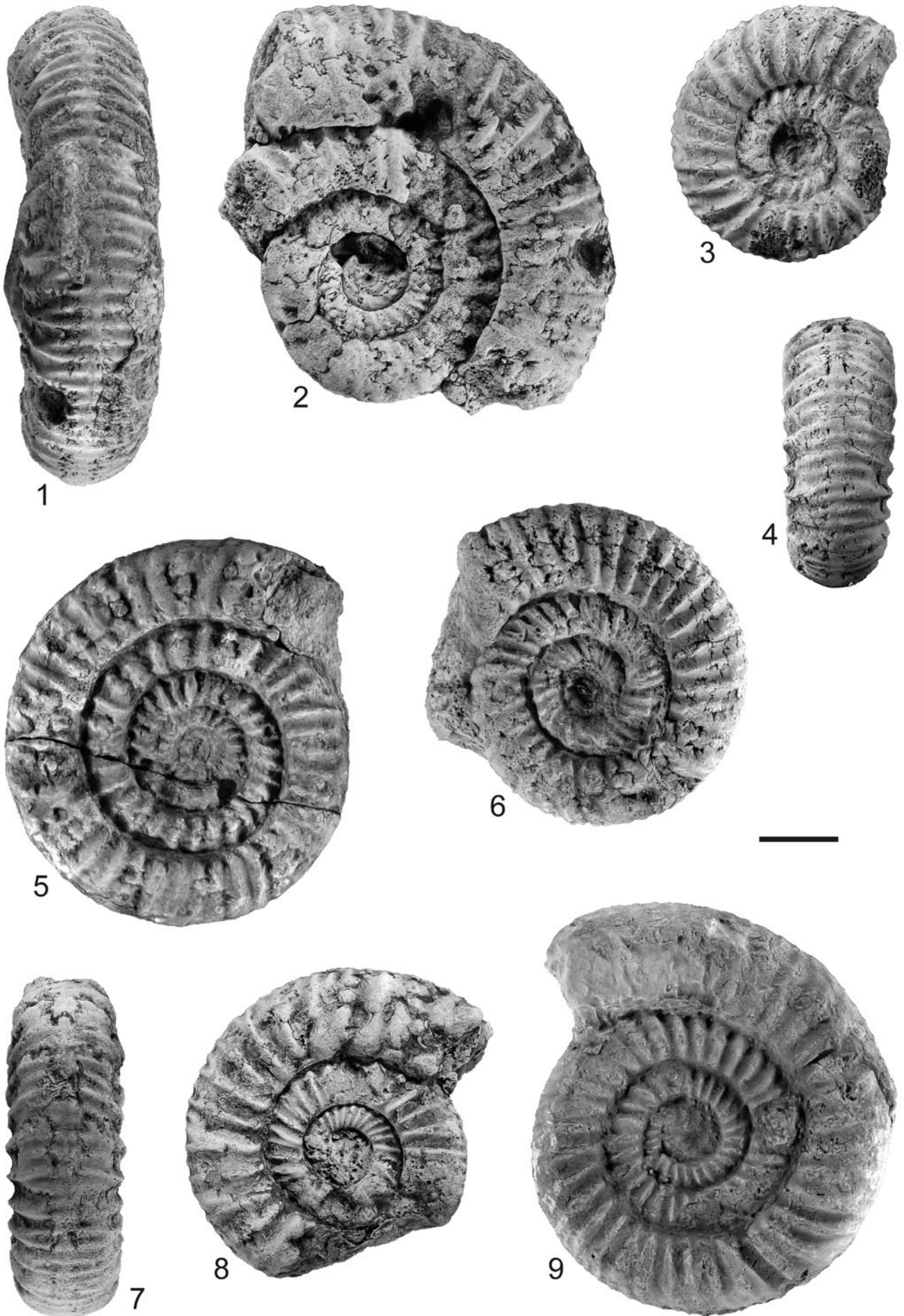


Plate XVIII

Figs. 1-5: *Perisphinctes (Dichotomoceras) stenocycloides* SIEMIRADZKI, 1898

- 1: lateral view of specimen GZN2010I 135 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift. No suture line is visible in the outer whorl.
- 2: lateral view of specimen GZN2010I 140 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift. No suture line is visible in the outer whorl.
- 3: ventral view of specimen GZN2010I 258, preserved with a part of the body chamber, from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.
- 4: lateral view of specimen GZN2010I 258, preserved with a part of the body chamber (the cross indicates the last visible septum), from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift.
- 5: ventral view of specimen GZN2010I 140 from the Kantkote Ammonite Beds in the Trama River, Wagad Uplift. No suture line is visible in the outer whorl.



10 mm

