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Additional Notes on the Fauna of the Spiti Shales.

By

MISS PAULA STEIGER,

Dr. Phil., University of Vienna.

PLATES CI to CIV.

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ADDITIONAL NOTES ON THE FAUNA OF THE SPITI SHALES.

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INTRODUCTION.

The following paper is the result of the study of certain fossils derived from the Spiti shales and entrusted to me for description by the late Professor V. Uhlig. Professor Uhlig's sudden death, unfortunately, deprived me of the opportunity of undertaking, under his direct supervision, the examination of these fossils, which were not dealt with in his monograph on the fauna of the Spiti shales,[1] and I have not, therefore, had the benefit of the experience and advice of our best authority on Jurassic faunæ. Although in my descriptions of the Ammonites of the Spiti shales I have endeavoured to follow Uhlig's main monograph as closely as possible, I have, perhaps, not succeeded completely in this task, because several of Uhlig's type-specimens were on their way to Calcutta when I began my examination, and I had access only to the collection of the Brothers Schlagintweit for a comparison of such materials as had been placed into my hands. I am, however, bound to admit that the figures in Uhlig's excellent monograph are of such eminent workmanship that I could afford to dispense with the type-specimens.

I began the examination of the Jurassic materials entrusted to me a few weeks before Professor Uhlig's mortal illness. After his death my work was continued in the Palæontological Museum of the University of Vienna under the supervision of Professor C. Diener, to whom my obligations for his kind assistance to me are great. To him and to Professor F. E. Suess I am, moreover, indebted for the grant of part of the Suess fund, which enabled me to study the Jurassic collections in the Palæontological Museum of Munich. To Professor Rothpletz I owe many thanks for the liberal aid afforded me in those studies. Finally, I wish to thank Professor G. v. Arthaber for his help in the literary portion of the work.

[1] Himalayan Fossils, *Palæontologia Indica*, ser. XV, Vol. IV.

DESCRIPTION OF SPECIES.

A.—AMMONOIDEA.

Gen. Perisphinctes Waag.

Sub-gen. Aulacosphinctes Uhlig.

Aulacosphinctes radialecostatus nov. sp.

(Plate CIII, fig. 3 *a*, *b*.)

Dimensions:—

2r	(*D*)	58 mm.	1
w		26 „	0·45
h_1		18 „	0·31
h_2		12 „	0·21
d		22 „	0·38

The volutions of this shell are overlapping each other to not quite one-half their height and lay open a deep umbilicus. Umbilical wall steep, flanks vaulted very strongly and passing gradually into the siphonal part, which is somewhat flattened. Transverse section considerably broader than high. Three-quarters of the last volution belong to the body-chamber. Its actual aperture cannot have been situated far off from the original peristome. Sutures, unfortunately, not in a satisfactory state of preservation.

Right over the umbilical belt very numerous and delicate ribs make their appearance. They are slightly turned forward in the inner volutions, but in the body-chamber whorl cross the flanks and siphonal area in a distinctly radial direction. The majority of ribs become dichotomous in the middle of the sides. Out of 56 costæ in the last volution four only remain undivided. That undivided ribs are also found on the inner volutions can be ascertained, as the place, where the ribs dichotomise, is clearly visible within the umbilicus. At the beginning of the body-chamber the ribs become slightly feebler as they approach the external part.

The present species is allied very closely to *Aulacosphinctes tibetanus* Uhlig,[2] agreeing with it in its dimensions, in the number and dichotomy of ribs, and in its transverse section. But the strictly radial direction of the ribs in the body-chamber and the strongly vaulted flanks impart to our form a peculiar aspect, which does not allow its identification with Uhlig's species. Nor do the external ribs diminish in strength in the body-chamber of *A. tibetanus*. There can be no doubt, consequently, that we are dealing with two distinct species.

Among other forms of the Spiti shales a relationship with the group of *Aulacosphinctes torquatus* might be taken into consideration. *Ammonites biplex* Blandford,[3] which has been united with *Aulacosphinctes torquatus* Sow. by

[2] The fauna of the Spiti shales, *l.c.*, p. 361, Pl. LXX, figs. 3, 4

[3] Blanford and Salter, Palæontology of Niti, Calcutta, 1865, Pl. XII, fig. 1, *non* Pl. XI, fig. 1.

Uhlig,[4] reminds us of our species by the direction of its ribs, but is easily distinguished by its high cross-section and by the strong flattening of its lateral parts.

Aulacosphinctes hundesianus Uhlig[5] is most nearly allied to the present form in the shape of its cross-section, but its ornamentation is stronger and less dense. Nor can the place of bifurcation of the ribs be seen within the umbilicus, which is narrower than in *A. radialecostatus*. In *A. infundibulum* Uhlig[6] the ribs are also less numerous and distinctly curved and deflected anteriorly.

Aulacosphinctes radialecostatus nov. sp. consequently represents a new connecting link between the two groups of this sub-genus, which have been distinguished by Uhlig. The discovery of such connecting links will, I earnestly hope, clearly prove the impossibility of establishing a sub-generic distinction between those two groups.

Locality, number of specimens examined.—This species is represented by a single specimen only from the Chidamu beds near Chidamu (coll. Diener).

Aulacosphinctes sp. ind. aff. Hollandi Uhl.

Aulacosphinctes cf. Hollandi Uhlig, The fauna of the Spiti shales, Palæont. Ind., ser. XV, Himalayan Foss., Vol. IV. p. 354, Pl. XLII, fig. 3.

A very flat shell, the inner volutions of which have been destroyed entirely. Lateral parts and siphonal area flattened. Transverse section somewhat broader than high, trapezoidal, with rounded-off corners. The last volution, the only one which has been preserved, belongs to the body-chamber. It is provided with a very distinct external furrow.

The following measurements have been noticed :—

2r	61 mm.	1
w	28 „	0·46
h_1	18 „	0·29
h_2	15 „	0·245
d	20 „	0·32

The ornamentation consists of sharp, narrow ribs, which rise in the umbilical wall, where they are slightly deflected backward. Across the flanks they run in a direction, which is slightly turned forward. The point of bifurcation lies a little above the middle of the height of the flanks. Across the siphonal area their direction is perfectly radial. Several shallow grooves are accompanied by irregularities in the ornamentation, such as intercalated ribs or undivided costæ. Fifty-seven main ribs are counted within the last volution.

This species is allied most nearly to *Aulacosphinctes Hollandi* Uhlig, especially to the form which has been referred to that species as *cf.* by Uhlig. The

[4] *l.c.*, p. 368.
[5] *l.c.*, p. 374, Pl. LXXI, fig. 3.
[6] *l.c.*, p. 371, Pl. LXXII, figs. 1, 2, 3.

larger number of ribs and the less distinct external furrow must be considered as the principal points of difference from the type. There is a nearly complete agreement in dimensions and involution. The transverse section of *A. cf. Hollandi* is not known, but in the type of *A. Hollandi* it is a little less high.

Among European forms *Aulacosphinctes eudichotomus* Zittel [7] is certainly the nearest ally to the present species, but is more involute and provided with a higher, not trapezoidal cross-section.

Locality, number of specimens examined.—Chidamu beds, Chidamu, one specimen (coll. Diener).

Aulacosphinctes nov. sp. aff. Lorioli Zitt.

(Plate CI, figs. 1 *a*—*b*, 2 *a*—*b*.)

Perisphinctes (Aulacosphinctes) nov. sp. aff. Lorioli Uhlig, The fauna of the Spiti shales, *l.c.*, p. 367.

Dimensions:—

2r	72 mm.		1
w	33 „		0·46
h_1	25 „		0·35
d	24 „	(approximately).	0·33

Flat, discoidal shell, with volutions embracing one another to one-half their height, and with a moderately deep umbilicus. Umbilical wall moderately steep, passing gradually into the lateral parts in the anterior portion of the body-chamber. Lateral parts flattened and converging remarkably towards the siphonal area. This area is comparatively narrow at the commencement of the body-chamber, but increases in relative width towards the aperture. Three-quarters of the last volution belong to the body-chamber, but the position of the original peristome could not be ascertained.

Sculpture consisting of strong, roof-shaped ribs, which are directed radially along the umbilical wall, without showing any trace of a deflection backwards. In the middle of the flanks the ribs bifurcate. They cross the siphonal area in a perfectly radial direction, without showing any trace of diminishing in strength. It is, however, probable that in the region of the air-chambers their strength in the ventral area is not quite equal to that on the lateral parts, as a difference is indicated in this respect at the beginning of the body-chamber.

There is one constriction in the last volution. The dichotomous rib preceding this constriction is united with the next in the umbilical region, the rib following the constrictions remains undivided. In the vicinity of the aperture a free intercalated rib is noticed. The place of bifurcation is laid open by the involution.

[7] Cephalopoden der Stramberger Schichten, *Mitteil. aus d. Museum des kgl. Bayr. Staates*, München, 1868, p. 112, Pl. XXI, figs. 6, 7.

Several constrictions are also noticed in the inner whorls, affecting the ornamentation in the same way as in the last whorl. In the last half volution twenty-five ribs are counted, none of them undivided.

To this species two fragmentary examples may be referred, which differ from the type in very slight details only. The umbilicus is marked off a little more sharply from the lateral parts, and the ribs are not perfectly radial, but are deflected forward very feebly. In one of those fragments a small portion of the chambered whorl next to the body-chamber volution is noticed to exhibit incomplete traces of the sutural line. The following sutural elements are accessible to examination. A narrow principal lateral saddle, a strongly oblique second lateral lobe, a first auxiliary lobe, which is very narrow, less deep than the lateral lobe and is united with the second lateral lobe and an accessory indentation into a suspensive lobe, which is sloping very slightly towards the umbilical suture. In both of those fragments the body-chamber cannot have been longer than one entire volution, perhaps even less. Near the termination of the last whorl a constriction is noticed in one of my fragments, measuring 5 mm. in width, which is accompanied by the change of ornamentation described above. The presence of this constriction leads to the conclusion that the actual peristome has not been very far off. The inner volutions are slightly depressed.

Professor Uhlig, in his short notice, assigned to the present species an intermediate position between *Perisphinctes sub-colubrinus* Waagen[8] and *P. Lorioli*, but promised to treat its description in greater detail in an appendix. As chief differences from *Aulacosphinctes Lorioli* he mentioned the lower volutions and wider umbilicus. To those features of distinction mentioned by Uhlig we must add the presence of constrictions, which are entirely absent in *P. Lorioli*, and the shallow ventral furrow, which has, however, been noticed in my two fragments only. Nor did I ever notice in our form the remarkable thickening of the ribs which is conspicuous in the siphonal area of *P. Lorioli*. On the other hand, the two species agree in the strength, direction and bifurcation of the ribs, and in the development of the sutural line, as far as this is known to us in the Indian type. It is specially the large fragment illustrated by Zittel, which in these characters reminds one strongly of our species. There is an equally close agreement between Zittel's species[9] and *P. Lorioli* Favre,[10] if we except the difference in the transverse section. On the other hand, *P. Lorioli* Kilian [11] is distinguished from the type and from our Himalayan species by more strongly curved ribs, which are bifurcating considerably above the middle of the height of the lateral parts.

[8] Jurassic fauna of Kutch, Cephalopoda, *Palæont. Ind.*, ser IX, Vol. I, p. 180, Pl. XLIX, fig. 3.

[9] Cephalopoden der Stramberger Schichten, *Mitteil. aus dem Museum des kgl. Bayr. Staates*, München, 1868, p. 103, Taf. XX, figs. 5, 6.

[10] Description des fossiles tithoniques des Alpes Fribourgeoises *Mém. Soc. Paléont. Suisse*, Vol. VI, Genève, 1880, p. 33, Pl. III, fig. 1.

[11] Mission d'Andalousie, *Mém. Acad. d Scienc. de l'Inst. de France*, Vol. XXX, Paris 1889, p. 652, Pl. XXVIII, fig. 3.

There would be no difficulty in distinguishing our Indian species from the European *P. Lorioli*, nor in justifying the introduction of a new name. Nevertheless, I deemed it preferable to leave the designation adopted by Uhlig in order to avoid mistakes, as this designation is met with repeatedly in Uhlig's monograph.

Notwithstanding the undoubtedly close relationship between our species and *Aulacosphinctes Lorioli*, several other congeneric forms must also be taken into consideration for comparison. With *Perisphinctes sub-colubrinus* Waagen it agrees in its involution and in the development of constrictions, although the latter are much more prominent in *P. sub-colubrinus*. An obvious distinction, however, exists in the round transverse section, the anteriorly deflected ribs and the later development of bifurcated costæ in Waagen's species.

Aulacosphinctes pseudocolubrinus Kilian [12] has a rounded transverse section and ribs bifurcating considerably above the middle of the height of the flanks, but resembles our species so closely in its involution, in the radial direction of the ribs and in their regular dichotomy, that the Indian species might well be considered as an intermediate link between *A. Lorioli* and *A. pseudocolubrinus* Kilian, whereas its affinity with *A. sub-colubrinus* Waagen is more distant. Perhaps, Uhlig himself had Kilian's species in view for a closer comparison and substituted *A. sub-colubrinus* in the text by mistake only. When discussing the stratigraphical value of the present species in his memoir[13] Die Fauna der Spitischiefer des Himalaya, ihr geologisches Alter und ihre Weltstellung, he lays a special stress on the Tithonian age of *A. pseudocolubrinus* and *A. Lorioli*, whereas Waagen's form from the Kuntkote sandstone of Kutch is characteristic of the topmost beds of the Oxford stage.

There is also a distant relationship between our species and *Aulacosphinctes Hollandi* Uhlig [14] which resemble each other in the arrangement of the ribs and in their involution, but differ considerably in their transverse sections and in the development of an external furrow. Of Mediterranean forms, it might be permissible to regard *Perisphinctes rectefurcatus* Zittel[15] as nearly allied to our species, although it differs from it in the density of ribs and in the height of its transverse section. *Perisphinctes Bleicheri* Loriol[16] at a first glance resembles the present species very strongly in the arrangement and dichotomy of ribs, but the square cross-section, the general shape of the European shell and its unusual dimensions show this striking resemblance to be no proof of any true affinity. *Perisphinctes Boidini* Loriol[17] has a similar cross-section, but more numerous ribs and the whorls more involute.

[12] Notes stratigraphiques sur les environs de Sisteron, *Bull. Soc. géol. de France*, 3e sér., Vol. XXIII, 1895, p. 679.

[13] *Denkschr. kais. Akad. Wissensch. Wien, math. nat. Kl.*, LXXXV, 1910, p. 21.

[14] *l.c.*, p. 353, Pl. XXXII, fig. 1.

[15] Die Fauna der aelteren Cephalopoden führenden Tithonbildungen, *Mitteil. aus d. Museum des kgl. Bayr. Staates*, 1868, p. 109, Taf. X, fig. 7.

[16] Monogr. paléont. et géol. des étages supér. de la faune Jurassique des environs de Boulogne sur Mer, *Mém. Soc. de Physique et d'hist. nat. de Genève*, Vol. XXIII, p. 273, Pl. IV, figs. 1, 2.

[17] *Ibid.*, Vol. XXIII, p. 274, Pl. IV, fig. 3, VII, fig. 1.

Locality, number of specimens examined.—Three specimens from Shangra, Gnari-Khorsum, coll. Schlagintweit, in the Palæontological Museum of Munich.

Aulacosphinctes aff. infundibulum Uhlig.

(Plate CII, fig. 3 *a*, *b*.)

Dimensions:—

2r	79 mm.	1
w	38 „	0·48
h	25 „	0·32
d	29 „	0·36

This species is represented by a well preserved cast, which in its general shape, involution, sculpture and in the development of a funnel-shaped umbilicus is closely allied to Uhlig's type of *Perisphinctes* (*Aulacosphinctes*) *infundibulum* Uhlig.[18] Nevertheless the identity of the two forms cannot be considered as complete. If we compare volutions of equal diameter, our specimen is proportionately less thick and its ribs are curved less strongly. Finally, the commencement of the body-chamber exhibits a change of ornamentation, which is but very faintly indicated in the typical *A. infundibulum*. This change in the typical sculpture consists in the development of an irregular sequence of undivided ribs, free intercalated costæ, dichotomous and tripartite ribs, in connection with numerous constrictions. The volution shows a considerable enlargement near the peristome. This enlargement begins as soon as the body-chamber has reached the length of one-half volution, but the total length of the body-chamber was probably not much less than one entire volution. The length of the body-chamber in the typical *A. infundibulum* is not known to us.

In none of the specimens examined by Uhlig has this characteristic terminal sculpture of the body-chamber whorl been noticed. It somewhat recalls the ornamentation in *A. Chidamensis* Uhlig,[19] although the pattern of trichotomy is different, the branching point of the oldest divided rib standing deepest. Occasionally, it is true, this pattern of trichotomy is also found in *A. Chidamensis*, although it is exceptional in that species.

The arrangement of the sutures agrees with that common to all representatives of the group of *Perisphinctes torquatus* Sow. An individual character of our species is the deep position of the principal lateral lobe, which is either equally deep or stands even at a lower level than the siphonal lobe. The second lateral and first auxiliary lobes are but slightly oblique. The umbilical suspensive lobe is consequently sloping very little, reaching only as far down as the inner lateral branch of the first lateral lobe.

Locality, number of specimens examined.—One specimen. Neither locality nor collection is indicated on the label accompanying it.

[18] Fauna of the Spiti shales, *l.c.*, Vol IV, p. 371, Pl. LXXII, figs. 14

[19] *l.c.*, p. 376, Pl. LXXIV, fig. 1.

AULACOSPHINCTES DIVERGENS nov. sp.

(Plate CI, fig. 3 *a*—*c*.)

Dimensions:—

2r	79 mm.	1
w	35 „	0·44
h_1	25 „	0·32
h_2	19 „	0·24
d	28 „	0·35

Whorls increasing rather rapidly and leaving a moderately deep umbilicus open. Involution equal to more than one-half the diameter of the shell. The last volution belongs entirely to the body-chamber. Its termination shows a considerable enlargement of the transverse section in the shape of a collar. This is the same pattern of peristome as has been described in *A. torquatus* Sow.

In the older portion of the body-chamber and in the region of air-chambers, the cross-section is slightly broader than high, trapezoidal, with lateral parts and siphonal area flattened. In this portion of the shell the ornamentation consists of a moderate number of strong ribs, which are dichotomising in the middle of the flanks, are slightly deflected backwards along the umbilical wall, and slightly turned forward on the lateral parts. They cross the siphonal area in a nearly radial direction. Undivided ribs also occur occasionally. A siphonal furrow originates at the beginning of the body-chamber.

This rather indifferent sculpture changes in the vicinity of the peristome. Here the ribs are arranged much more closely. Among fifty-five ribs, which are counted in the last whorl, not less than twenty belong to the last quarter. The backward deflection along the umbilical wall is marked very strongly, single, undivided ribs become more numerous (one to three or four dichotomous ones) and the branching points are descending gradually to a lower level. With this change in the ornamentation a considerable change in the growth of the shell is united. The volution increases in height and thickness, lateral and siphonal parts are rounded more strongly and pass gradually into one another.

Trichotomy of ribs is entirely absent in this species. Constrictions have not been noticed. Sutural line unknown.

In sculpture and involution the older portion of the body-chamber in this species reminds one of the group of *Perisphinctes torquatus* Sow. I have been able to secure for comparison the type-specimen of *P. torquatus*, which has been illustrated by Sowerby [20] and Uhlig.[21] In its general shape and involution it is very closely allied to *Aulacosphinctes divergens*, but differs from it by the regular density of its ribs, by the absence of undivided main ribs and by the presence of free intercalated ribs. There certainly exist specimens of *P. torquatus*, in which undivided ribs are developed exceptionally, but their frequency, especially near the aperture in *A. divergens*, is unparalleled in any form belonging

[20] Fossils from Kutch, *Transact. Geol. Soc. London*, 2d. ser., Vol. V, 1840, Pl. LXI, fig. 12.

[21] Fauna of the Spiti shales, *l.c.*, Pl. LXXI.

to the group of *A. torquatus*. This character, as well as the density of ribbing, increasing in general towards the aperture, impart to our form an isolated position among the representatives of the group of *A. torquatus*. All species of this group hitherto described show the following tendency of development. In the vicinity of the aperture the ribs become more distant, and are divided several times or alternating with intercalated costæ. In the present species, on the contrary, the ribs are more crowded, and single ribs become more frequent in the direction towards the peristome.

The lateral enlargement of the peristome has been described by Uhlig in *Aulacosphinctes torquatus* Sow.[22] and *A. Willisi* Uhlig.[23] In our species this enlargement is of the same pattern as in *A. torquatus*, but the possibility of this character existing in many species of *Aulacosphinctes* cannot be denied, there being very few examples known to us with their peristomes preserved entirely. The cross-section of *A. divergens* resembles most closely that in *A. sub-torquatus* Uhlig.[24]

Among the rest of European and Indian representatives of the sub-genus *Aulacosphinctes*, no species is closely related to *A. divergens*. The ornamentation of *Perisphinctes transitorius* Zittel,[25] it is true, reminds one of the terminal sculpture in *A. divergens*, excepting for the absence of undivided ribs, but in this European Ammonite the same pattern of sculpture prevails in the inner and outer whorls. This similarity is only an external one, *P. transitorius* differing from our species remarkably in its involution and cross-section.

Locality, number of specimens examined.—Of *Aulacosphinctes divergens*, one single specimen only is known to me from Shangra. Gnari-Khorsum. coll. Schlagintweit.

Aulacosphinctes sp. ind.

A fragment, consisting of two body-chamber whorls following one another, is lying before me. Its transverse section is broader than high, sub-trapezoidal, with lateral and siphonal parts flattened. All the ribs are dichotomous, deflected forward slightly on the inner whorl, but perfectly radial in the outer volution, where they are developed in uncommon strength and separated by deep intercostal valleys.

No siphonal furrow is present, but their absence on the chambered portion of the shell cannot be ascertained, no air-chambers being available for examination. The length of the body-chamber cannot be less than one entire volution.

This fragment can, undoubtedly, be classed with the nearest allies of the group of *Aulacosphinctes torquatus* Sow., but must probably be referred to a new species. In the feeble deflection of its forward-turned ribs, it reminds one

[22] *l.c.*, p. 369. Pl. LXIX, fig. 2c.

[23] *l.c.*, p. 374.

[24] *l.c.*, p. 367, Pl. LXX, fig. 1.

[25] Cephalopoden der Stramberger Schichten, *Mitt. aus dem Museum des kgl. Bayr. Staates*, München, 1868, p. 103, Taf. XXII, figs. 1—6.

of the true *A. torquatus*, in the shape of the cross-section and in the flattening of its lateral parts of *A. Willisi* Uhlig.[25] *A. torquatus* has a more square-shaped and higher transverse section. *A. Willisi* is distinguished by the presence of ribs deflected forward very strongly. From all other species of the group of *A. torquatus* the present one differs by the remarkable strength of the ribs in the last volution and by the difference in the direction of ribs in the two whorls preserved. Strong ribs have also been noticed in *A. ophioides* by Uhlig,[27] which is, however, more evolute and has a higher cross-section, especially in the older whorls. A contrast in the direction of ribs is known to me in *Perisphinctes Fontannei* Choffat,[28] which is otherwise entirely different from our species.

The incomplete state of preservation precludes a more exact description of this interesting species, which must be postponed until further opportunities arise.

Locality, number of specimens examined.—One fragmentary specimen from Shangra, Gnari-Khorsum, coll. Schlagintweit.

AULACOSPHINCTES SHANGRAENSIS nov. nom.

(Plate CIII, fig. 2 *a*—*c*.)

Perisphinctes Bleicheri Waagen, Jurassic fauna Kutch, 1, Cephalopoda. Palæont. Ind., ser. IX, Vol. I, p. 194, Pl. LV, fig. 1.

Shell discoidal, with a moderately deep umbilicus. Umbilical wall moderately steep in the inner whorls, passing into the flanks very gradually in the body-chamber.

Dimensions:—

	My specimen			Waagen's species.		
2r	91 mm.	1		2r	66 mm.	1
w	41 „	0·44		w	28 „	0·42
h	34 „	0·36		h	24 „	0·36
d	34 „	0·36		d	25 „	0·37

Although the cross-section cannot be observed directly, its shape can be made out satisfactorily from the measurements of the lateral and siphonal parts. It is square-shaped, with rounded-off corners in the body-chamber, but becomes slightly trapezoidal in the inner volutions, the transverse diameter being a little larger in the umbilical than in the siphonal region. Flanks regularly and flatly curved, siphonal area slightly flattened. An external furrow is not developed distinctly, but the cast of a siphonal area along the internal side of the oldest volution exhibits traces of an obliteration of the ribs along the median line, although they are not interrupted.

Three-quarters of the last volution belong to the body-chamber. The actual peristome cannot have been situated far off from the aperture, as this is provided with a considerable enlargement of the transverse section.

[26] Fauna of the Spiti shales, *l.c.*, p. 373. Pl. LXV, fig. 3, LXXIII, fig. 1.

[27] Fauna of the Spiti shales, *l.c.*, p. 363, Pl. LI.

[28] Déscription de la faune Jurassique du Portugal, Céphalopodes, I sér., Ammonites du Lusitanien, *Direct. travaux géol. d. Portugal*, Lisbonne, 1893, p. 40, Pl. IX.

Ribs flatly curved, originating in the umbilical wall, where they are deflected backward slightly, whereas they are turned forward along the flanks. They cross the siphonal area in a radial direction. Thus the ribs are slightly falciform in their general arrangement. They bifurcate in the middle of the flanks, the secondary costæ, which are formed by this bifurcation, diverging but very little. This bifurcation is a character common to all the ribs on the body-chamber and on the whorl preceding the last volution. In the inner whorls, however, some ribs remain undivided and one trichotomous rib is noticed in connection with a delicate constriction. Otherwise no trace of constrictions has been noticed. In the inner whorls the branching points of the ribs must be situated at a lower level, because they become visible within the umbilicus. Forty-eight main ribs are counted in a volution corresponding to a diameter of 70. mm.

Sutures.—The sutural line shows the arrangement characteristic of *Aulacosphinctes torquatus* Sow. The siphonal lobe has two very long and narrow branches. Its lateral branches bordering the interior wall are deeply ramified. Siphonal saddle bipartite, with a deep secondary lobe, which divides this saddle into a narrow, higher and a very broad deeper portion. Principal lateral lobe comparatively narrow, less deep than the siphonal lobe, with a strong lateral branch on either side. Principal lateral saddle bipartite, higher than the siphonal saddle, richly ramified, with stems laced very strongly. Inner branch of this saddle exceeding the outer in height. Second lateral lobe slightly oblique, its terminal point standing at equal level with the inner lateral branch of the principal lateral lobe. Second lateral saddle bipartite, considerably lower than the principal one, differing from the latter in the proportion of the relative height of its two branches. First auxiliary lobe strongly oblique, deeper than the second lateral lobe but somewhat less deep than the principal one. First auxiliary saddle entire. It is followed by one more lobe and two denticulations, this umbilical lobe standing at an equal level with the principal lateral lobe.

The species, which has been referred to *Perisphinctes Bleicheri* Lor. by Waagen,[29] agrees with the present one in its general shape and ornamentation so closely that I do not hesitate in uniting them. This identification is corroborated by the fact that they occur in the same zoo-geographical province. The only diagnostic character, which might be advocated in favour of a specific distinction, is the slightly wider umbilicus in Waagen's specimen. The presence of constrictions is mentioned in Waagen's description, but in his illustration no constrictions have been indicated. In our Himalayan form constrictions are restricted to the adolescent stage of the shell.

Waagen, it is true, emphasizes the simple character of the sutures, which, according to him, are not ramified strongly and show the auxiliary series arranged in an approximately straight line. This difference in the character of the sutural lines would suffice to prevent any identification, but I must lay special stress on Waagen's own remark, that in his type-specimen the sutures were preserved very badly and that in his illustration, which undoubtedly represents

[29] *l.c.*, p. 194, Pl. LV. fig. 4.

the better preserved, side of the shell only one single volution—the body-chamber whorl, according to Waagen—has been drawn by the artist. From this I infer that the older whorls have been destroyed completely and that the sutures were not accessible to examination in a satisfactory manner. I, consequently, feel justified in neglecting Waagen's remarks regarding the simple arrangement of the sutures and the straight umbilical lobe in his specimen, and I deem it preferable to unite the two forms, which, with more abundant materials at hand for comparison, might probably prove to be specifically identical.

Waagen identified his specimen from Kutch with *Perisphinctes Bleicheri* Loriol[30] from the Portlandian of Boulogne sur Mer. The Indian form is certainly very closely allied to this European species. Nevertheless a closer comparison of Waagen's and E. de Loriol's illustrations induces me to agree with Siemiradzki[31] and Uhlig (Fauna of the Spiti shales, *l.c.*, *p.* 380) in rejecting a direct identification. The two specimens figured by Loriol under the name of *Perisphinctes Bleicheri*, which Uhlig is inclined to consider as two separate species, agree, notwithstanding several features of distinction, in the development of perfectly radial ribs, a character whose importance has been specially emphasized by Loriol himself. Although Waagen in his description speaks of " nearly radial ribs," his illustration shows the ribs to be of a remarkably falciform shape, exactly as in the Himalayan specimen. Were the falciform shape of the ribs in Waagen's illustration due to a mistake of the artist, Waagen could scarcely have failed to mention it in the text, this character playing a most important part in the general shape of the ornamentation. On the other hand, I find it impossible to unite Waagen's specimen with *Perisphinctes transitorius* Zittel, as has been advocated by Siemiradzki.[32] Differences in the involution, in the shape of the cross-section and the absence of an external furrow demand a specific separation. The close affinity of the Ammonite from Kutch with *Perisphinctes Bleicheri* cannot be denied. Waagen's form and the present species from the Spiti shales exhibit a very strong resemblance to Loriol's species from the Portlandian of the Boulonnais in their involution and transverse sections, but the curvature of the ribs and the absence of trichotomous costæ involve the necessity of a specific separation. As it is not possible to continue applying the name " *Bleicheri* " to the Indian form, the latter must receive a new denomination. Its principal characters being known to us, including even the sutural line, I do not hesitate in introducing a new name " *Shangraensis*."

Owing to the similarity of the sutures, one might feel inclined to include *Perisphinctes Shangraensis* in the group of *Aulacosphinctes torquatus* Sow., although it differs from all the Himalayan representatives of this group. If we look out for nearly allied forms, we meet with a number of species, whose affinity with *Perisphinctes Bleicheri* Lor. has been noticed by Uhlig. Among them we

[30] Monographie paléont et géol. des étages supér. de la faune des environs de Boulogne s. Mer, *Mém. Soc. d. Phys. et d'histoire nat de Geneve*, Vol. XXIII, p. 273, Pl. IV, figs 1, 2.

[31] Monograph. Beschreibung der. Ammonitengattung Perisphinctes, *Palæontographica*, Vol. XLV, 1899, p 174.

[32] *l.c.*, p. 164.

find *Aulacosphinctes Smith-Woodwardi* Uhlig,[33] which agrees with our form in its involution and in the falciform character of the ribs, but differs by its strongly compressed whorls, by less densely crowded and sharper ribs, and by the higher position of the branching points of the ribs, especially in the inner whorls.

From *Perisphinctes biplicatus* Uhlig [34] our species is distinguished by its ribs being more strongly curved, by the gradual passage of the lateral parts into the umbilical wall and by the different arrangement of the sutures. *Aulacosphinctes ophioides* Uhlig[35] has a wider umbilicus, undivided ribs and a different sutural line.

The problem of relationship is complicated by the fact that the sutural line of *Perisphinctes Bleicheri* Lor. is, unfortunately, not known to us. Provided *P. Bleicheri* possessed the sutures of *P. torquatus*, a close affinity of this European type with the present form and with the group of *Aulacosphinctes torquatus* in the Spiti shales might be considered as certain. On the other hand, we cannot yet exclude the possibility of the sutures of *P. Bleicheri* agreeing with those of *P. biplicatus* Uhlig, thus revealing the true affinity of this hitherto isolated species. In favour of this suggestion is the arrangement of the sutures of *Perisphinctes Boidini* Loriol,[36] which occurs in the same beds as *P. Bleicheri* and appears to be closely related to it. *P. Boidini* has very broad saddles and an umbilical lobe which is sloping very little only. This is also the pattern of sutures in *P. biplicatus*. Typical inner nuclei of *P. Bleicheri* with their sutures preserved not being known, it is not possible for the present to determine with sufficient precision its degree of relationship to either *P. Shangraensis* or *P biplicatus*.

There exists only a distant external resemblance with several other forms from the Spiti shales. From *P. intermedius* Uhlig[37] it differs by the square shape of its cross-section, by the absence of trichotomous ribs, and by a more narrow principal lateral lobe and siphonal saddle. *Virgatosphinctes Pompeckyi* Uhlig[38] recalls our species in its ornamentation, but is more evolute and differs in the shape of its transverse section and in the arrangement of the sutures. *Virgatosphinctes subquadratus* Uhlig[39] is distinguished by its involution and by the presence of trichotomous ribs which are deflected forward very strongly, notwithstanding a considerable agreement in ornamentation at the commencement of the body-chamber. *Virgatosphinctes aff. pseudolictor* Burckhardt[40] resembles our species in the arrangement of the sutures, in involution and in the curvature of the ribs, but is easily distinguished by the sharp angle separating the flanks

[33] Fauna of the Spiti shales. *l.c.*, p. 372, Pl. LXIX, fig. 1.
[34] *l.c.*, p. 379, Pl. LVII.
[35] *l.c.*, p. 363, Pl. LI.
[36] *l.c.*, p. 274, Pl. VII, fig. 1
[37] *l.c.*, Pl. LXVI, fig. 1. p. 319.
[38] *l.c.*, p. 320, Pl. LXV.
[39] *l.c.*, p. 338, Pl. LXVIII, fig. 1.
[40] Beitraege zur Kenntnis des Jura und der Kreideformation der Cordillere. *Paleontographica*, L, 1903, 1903, p. 36, Taf. IV, figs. 1—6.

from the umbilical wall, by the frequent division of the ribs in the body-chamber, by its lateral parts converging strongly towards the siphonal area, and by the position of the siphonal and principal lateral lobes which are standing at the same level.

Perisphinctes Bleicheri Waagen (*non* Lor.) has been grouped with the sub-genus *Aulacosphinctes* by Uhlig without any special reasons being given for this reference.[41] He probably considered the general shape and involution of the species sufficient for this classification, the absence of an external furrow being easily explained by the unsatisfactory knowledge of the air-chambers. The description of the present specimen adds to our knowledge of the general shape of the Indian form, the development of a sutural line agreeing with that characteristic of the group of *Perisphinctes torquatus*, and the discovery of the beginnings of an obliteration of the sculpture in the siphonal region of the innermost whorls. Nevertheless the reference to *Aulacosphinctes* is questionable.

Uhlig himself was well aware of the fact "that the definiteness of the sub-genus *Aulacosphinctes* is greatly obscured by the inclusion of the group of *Perisphinctes torquatus* and that it would possibly be preferable to create for them a separate sub-genus." Taking into consideration that many forms of the *torquatus* group are allied to typical *Aulacosphinctes* more closely than *Perisphinctes Shangraensis* is to the group of *P. torquatus*, we have to be careful in referring our species to *Aulacosphinctes*, no connecting links being as yet known to us. It is not advisable to depreciate the value of an exactly defined sub-genus within the genus *Perisphinctes* by the inclusion of a species which does not show all the peculiarities common to its typical representatives.

Locality, number of specimens examined.—One specimen from Shangra, Gnári-Khorsum, coll. Schlagintweit.

Sub-gen. VIRGATOSPHINCTES Uhlig.

VIRGATOSPHINCTES CONTIGUUS Toucas.

(Plate CI, fig. 4.)

Ammonites contiguus, Toucas, Faune des couches tithoniques de l'Ardèche, Bull. Soc. Géol. de France, 3ème ser., Vol. XVIII, p. 581, Pl. XIV, fig. 4.
Non *Ammonites contiguus* Catullo, Zittel, Vetters, Uhlig, Burckhardt, etc.

Shell discoidal with a comparatively shallow umbilicus, volutions embracing one another to about one-half their height. Lateral parts slightly flattened, converging in the direction towards the siphonal area which is feebly vaulted. Transverse section of equal width and height at the beginning of the body-chamber. Near the aperture the height exceeds the breadth, although very inconsiderably. Greatest transverse diamater always corresponding with the umbilical margin. Three-quarters of the last volution belong to the body-chamber. The

[41] *l.c.*, p. 348.

oral margin has not been preserved, nor are any traces of its proximity visible at the aperture. Umbilical wall perpendicular.

Dimensions:—

2r	68 mm.	1
w	31 „	0·455
h	22 „	0·32

Sculpture consisting of very stout, bulky ribs which originate in the umbilical wall and cross it in a curve which is slightly turned backward, but the lateral parts in a curve feebly deflected forwards. A short distance below the middle of the flanks the majority of ribs bifurcate, but a small number, seven or eight, become trichotomous exhibiting a virgatotomous sculpture, the first branch rib being separated from the main stem in the lowest third part of the flanks, the second bifurcation following at the same level as in the dichotomous ribs.

At the commencement of the body-chamber a very shallow external furrow has been noticed. Constrictions are rare and not prominent. A somewhat stronger constriction is found near the termination of the whorl only. In one single case the anterior secondary rib remains independent and may be traced as far as the umbilicus in the shape of a very delicate line. Forty-six ribs altogether have been counted in the last volution.

Sutures.—Not known.

The present species belongs to the group of *Perisphinctes contiguus.* As has been remarked by Vetters and Uhlig, a considerable number of different species have been united under this denomination The revision of the entire material is desirable before the state of confusion regarding the synonymy of this group can be abolished. For the present I prefer to follow Uhlig[42] in restricting the name to the Indian form described here and the identical European form of the group—excluding the rest of the synonyms.

Among all the European species mentioned under the collective name of *Perisphinctes contiguus* the species from Ardèche described by Toucas is the only one which agrees entirely with our Himalayan form. In involution, number, strength and bifurcation of ribs no difference can be found between my specimen and the illustration given by Toucas. The shape of the cross-section is not mentioned by this author, but as far as we may judge from the illustration it cannot differ considerably from that which has been noticed in our species. In the Jurassic rocks of the Ardèche two varieties are said to occur together with the type described by Toucas. Our Himalayan specimen must be identified with the type. The smaller number of trichotomous ribs, which might indicate an identity with Toucas' variety *b*, is easily explained by the smaller dimensions of my specimen. If we compare examples of equal size from the Spiti shales and from Ardèche, they show an equal number of trichotomous ribs. In var. *b* these trichotomous ribs are said to be replaced occasionally by undivided

[42] Fauna of the Spiti shales, *l.c.*, p. 328.

costæ which is never the case in our Himalayan form. Toucas himself mentions the presence of a feeble obliteration of the siphonal sculpture in some of his examples from Ardèche which, consequently, agree with our form in this feature.

Catullo's original type of *Perisphinctes contiguus*[43] is distinguished from all the other forms, which have been united with this species, by the high position of the deeper branching points of the trichotomous ribs. This point stands at an equal level with the branching points of dichotomous ribs, whereas in all other forms of the group the branching points of dichotomous ribs stand at the same level as the higher branching point of trichotomous ribs. The effect of this apparently small difference is, that in Catullo's specimen the dichotomous ribs are found only with difficulty and after some trouble. whereas in all other forms of the group the alternation of dichotomous and trichotomous ribs is the most striking feature in the ornamentation of the shell. The possibility of this remarkable difference in the sculpture of Catullo's and Zittel's types[44] being due to a mistake of Catullo's artist cannot be denied. This was at least Zittel's view. Toucas united his type with the species in the circumscribed sense proposed by Zittel, but this identification was rejected by Uhlig without any comment.[45] Less involute whorls, smaller height of the transverse section and a less dense but stronger ribbing seem to justify, provisionally at least, a specific separation of Toucas' type together with the present species on the one hand from *Perisphinctes contiguus* in the interpretation of Zittel, Vetters[46] and Uhlig on the other.

The introduction of a new name for this variety had better be postponed until a thorough revision of Zittel's rich material has been accomplished. This revision will either show the impossibility of separating the numerous forms mentioned under the collective name of *P. contiguus* on account of the presence of transitional shapes connecting them or it will prove the necessity of distinguishing our Himalayan form as a proper species. But the decision must needs depend on the future revision of Zittel's European materials.

From a small number of other forms, to which the name "*contiguus*" has also been applied. our species can be distinguished with less difficulty. *Perisphinctes contiguus* Burckhardt,[47] of which a plaster-cast is before me, is more involute and high, ribbed more densely and delicately, and the branching points of ribs are situated closer to the siphonal area, the first branching point of the trichotomous ribs being shifted to the middle of the flanks or even a little higher. Zittel, it is true, has confirmed Burckhardt's identification of the American form with his European type. It is certainly not identical with the specimen repre-

[43] Intorno ad una nuova classificazione delle calcarie rosse ammonitiche delle Alpi Venete, *Mem. Instituto R. Veneto d. scienze, letted. arti*, Vol. V, 1857, p. 214, Pl. III, fig. 4.

[44] Die Fauna d. älteren Cephalopoden führenden Tithon bildungen, *Mitteil. aus d. Museum d. kgl. Bayr. Staates*, Muenchen, 1868, p. 110, Taf. XI, fig. 2, *non* 1.

[45] *l.c.*, p. 339.

[46] Die Fauna der Juraklippen zwischen Donau und Thaya, I, Tithon von Niederfellabrunn, *Beitr. z. Geol. u. Palaeontologie Oesterr.-Ung., etc.*, XVII, 1905, p. 235, Taf. XXII, fig. 7.

[47] Beitraege z. Kenntnis der Jura-und Kreideformation der Cordillere, *Palæontographica*, L, 1903, p. 38, Taf. IV, figs. 7—10.

sented in Zittel's illustration on Plate XI, fig. 2, but there is no reason why this variety should not be found in Zittel's rich materials.

More closely allied to our Himalayan species is *Perisphinctes dorsoplanus* Burckhardt, which Vetters and Uhlig prefer to group with *Virgatosphinctes contiguus* rather than with *Virgatites*, especially in the density and strength of ribbing. It differs, however, by the higher position of the branching points, by its ribs being curved forward more strongly, and by its lateral parts converging less strongly. *Perisphinctes contiguus* Favre[48] has a wider umbilicus and the branching points situated at a higher level. The specimen illustrated by Pavlow[49] might also be mentioned here. Notwithstanding its large dimensions a fragment of the outer volution and the innermost biplicate whorls only have been preserved. The most characteristic stage, distinguished by the development of a virgatotomous-triplicate sculpture, is not accessible to examination. It is therefore not possible for the present to determine with sufficient precision its degree of relationship to the sub-genus *Virgatosphinctes.*

Our species can scarcely be mistaken for any Jurassic form outside the group of *P. contiguus.* A few similar forms have been described from the Spiti shales, but are distinguished easily. In *Virgatosphinctes incertus* Uhlig[50] the cross-section is distinctly depressed and the ribs are curved strongly. *Virgatosphinctes cf. adelus* Gemm.[51] differs by the shape of its transverse section and by the absence of a virgatotomous trichotomy of its ribs. In *V. sparsicosta* Uhlig[52] the ribs are less dense and show a different pattern of bifurcation.

In favour of a grouping of the present species with the sub-genus *Virgatosphinctes* the following reason can be urged. The species clearly and indubitably shows the virgatotomous sculpture. Although the presence of a feebly marked siphonal furrow conflicts with a reference to *Virgatosphinctes*, this character does not possess any deeper significance. Nor would it justify a separation of our species from the group, to which it is otherwise most nearly allied. Uhlig himself remarks[53] that future researches might probably reveal the presence of an external furrow in some species of *Virgatosphinctes* and might thus somewhat obliterate the sharp boundary between *Virgatosphinctes* and *Aulacosphinctes.* My materials are too scanty to decide this question. I am, however, bound to remark that Toucas has noticed traces of an external furrow in his European specimen and that this feature has also been observed in *Perisphinctes dorsoplanus* by Burckhardt. From such observations it is evident that external furrows are feebly indicated in a group, which Uhlig himself united with his sub-genus *Virgatosphinctes*

[48] La zone à Ammonites acanthicus des Alpes de la Suisse, *Mém. Soc. Paléontolog. de la Suisse*, Vol. IV, Genève, 1877, p. 48, Pl. IV, fig. 2.

[49] Les Ammonites de la zone à Aspidoceras acanthicum dans l'Est de la Russie, *Mém. Com. Géol. St. Pétersbourg*, Vol. II, 1886. Pl. VIII, fig. 3.

[50] *l.c.*, p. 342, Pl. LXVII, fig. 2.

[51] Uhlig, *l.c.*, p. 375. Pl. LXVII, fig. 1.

[52] *l.c.*, p. 377. Pl. LXXIV.

[53] *l.c.*, p. 349.

Locality, number of specimens examined.—One specimen from Shangra, Gnari-Khorsum, coll. Schlagintweit.

Virgatosphinctes sp. ind.

A fragment of a specimen with a diameter of ab. 75 mm. reminds one in its transverse section and in its ornamentation of *Virgatosphinctes serpentinus* Uhlig.[54] Inner volutions covered with numerous dichotomous ribs. In the last volution trichotomous and even quadrotomous bifurcations of ribs occur frequently, much more frequently indeed than in specimens of *V. serpentinus* of equal size. There is no other species among the forms described by Uhlig, which might be compared more closely with the present one, which is certainly new, although its defective state of preservation precludes any exact determination.

Fresh discoveries must be awaited in order to enable us to define this interesting species more accurately.

The specimen belongs to the coll. Schlagintweit. Locality not known.

Virgatosphinctes nov. sp. ind.

(Plate CIV, fig. 2 *a*, *b*.)

Dimensions:—

2r	44 mm.	1
h_1	20 „	0·45
h_2	15 „	0·34
d	16 „	0·35
w	15 „	0·34

This new species is allied very closely to *Virgatosphinctes sp. ind. aff. denseplicatus* (Waag.).[55] In sculpture and in the arrangement of the sutural line the two agree so closely that I may refer the reader to Uhlig's description. Nevertheless a direct identification is rendered impossible by a remarkable difference in the shape of the cross-section, which in the last volution of our species is high, narrow and converging towards the siphonal area, thus making the largest transverse diameter correspond with the umbilical margin. Among the species of the group of *Virgatosphinctes denseplicatus*, which have been illustrated by Uhlig, there is no form with a similar cross-section.

In our new species the compressed shape of the cross section is restricted to the last volution. In the penultimate whorl this section is strongly depressed, thus indicating a very rapid change of the lumen from a depressed into a compressed shape. Uhlig's description and illustration of his types of the *denseplicatus* group give us no clue as to the shape of the adolescent stage. Inner volutions were probably not known to him. Waagen* says that the whorls become gradually more depressed as they advance in age. But the inner nucleus of his

[54] Fauna of the Spiti shales, *l.c.*, p. 322, Pl. LII, fig. 2.

[55] Uhlig, Fauna of the Spiti shales, *l.c.* p 324, Pl. LXV, fig. 2.

* Jurassic fauna of Kutch, I, Cephalopoda, *Palæontol. Ind.*, ser IX, Vol. I, 1873, p. 202.

species was not known to him, and consequently its agreement with the whorls of middle stages of growth cannot be ascertained.

The remarkable change in the shape of the cross-section, which is characteristic of our species, has been met with in the group of *Perisphinctes unicomptus*. In this respect two species of the latter group agree very closely with the present form, *Perisphinctes Castroi* Choffat,[56] which is identical with *P. lusitanicus* Siemiradzki[57] and *P. cf. Lusitanicus* Dacqué[58] from East Africa. They agree in involution and sculpture, but differences are noticed in the coarser ribbing and in the sutures, the principal lateral saddle being shorter than the siphonal saddle and the first auxiliary lobe being developed more distinctly.

My materials are too scanty to determine with any precision the relationship of the present species to *Perisphinctes denseplicatus* or *P. lusitanicus*. My type-specimen consists of air-chambers only. A second, badly preserved example is probably also referable to this species, as far as we may judge from its narrow, high transverse section.

The fragment, which has been preserved more satisfactorily, has been collected by Griesbach. The locality is marked on the accompanying label: "Some 25 miles equidistant from the crest of the Niti pass and from Iwani Irigunatita." The second specimen is from Chidamu, coll. Diener.

Isolated Types.

Perisphinctes Dacquei nov. sp.

(Plate CII, figs. 1 *a*—*c*, 2 *a*—*c*.)

Perisphinctes (Virgatosphinctes?) nov. sp. ind. Uhlig, Fauna of the Spiti shales, *l.c.*, p. 341.

Dimensions:—

2r	78 mm.	1	2r	100 mm.	1
w	33 „	0·42	w		
h_1	27 „	0·345	h_1	29 „	0·29
h_2	21 „	0·27	h_2	24 „	0·24
d	32 „	0·4	d	36 „	0·36

The involutions of my type-specimen are enveloping one another to one-half their height. Umbilicus deep, surrounded by a moderately steep umbilical wall. Transverse section broader than high, lateral and siphonal parts curved in the chambered portion of the shell, flattened in the body-chamber. The last half volution belongs to the body-chamber, which is, however, not complete.

Sculpture consisting of rounded ribs, resembling those in *P. plicatilis*. They originate in the umbilical margin and cross the flanks in a radial direction, which

[56] Descr. de la faune Jurassique du Portugal, Céphalopodes, I sér., Ammonites du Lusitanien, *Direct. travaux géol. du Portugal*, Lisbonne, 1893, p. 43, Pl. X, figs. 4, 5.

[57] Monographische Beschr. d. Ammonitengattung Perisphinctes, *Palæontographica*, XLV, 1899, p. 277.

[58] Dogger und Malm aus Ostafrika, *Beitraege z. Geol. u. Palaeontol. Oesterr.-Ungarns, etc.*, XXIII, 1910, p. 22, Taf. I.

is followed by a slight forward curve. Above the median line of the lateral parts they are divided in two branches, which keep the direction of the main ribs and pass across the siphonal area in a very shallow curve. Forty-seven ribs are counted in the last chambered volution and 24 in the half whorl corresponding to the body-chamber. Although the number of ribs is not subject to any change in the body-chamber, the sculpture becomes less dense and stronger. In the body-chamber in one case only virgatotomous trichotomy of the ribs has been noticed outside the region of constrictions, to which this sort of bifurcation is restricted otherwise. Two such constrictions are found in every volution, each of them being preceded by a trichotomous and followed by an undivided rib. Along the siphonal area the ribs are flattened considerably, but no distinct external furrow is developed.

Besides my type-specimen there is a second fragment before me, with a diameter reaching almost 100 mm. It differs from the former, especially by its large dimensions, consisting entirely of air-chambers, but agrees with it completely in its shape, cross-section and ornamentation. The sculpture seems to undergo no change during all the stages of growth. Dichotomy of the ribs prevails. Once only trichotomy has been noticed and several times the presence of short intercalated ribs.

In this fragment the sutural line has been preserved remarkably well, although not completely. It is very strongly ramified. Principal lateral lobe less deep than the siphonal lobe, broad and richly serrated. Second lateral lobe slightly oblique, broad and short, not reaching the depth of the main inner branch of the principal lateral lobe. It is tightened remarkably by this latter and by the first auxiliary lobe. A short secondary lobe separates the second lateral from the first auxiliary lobe, which is directed radially, developed very strongly and equal in depth to the principal lateral lobe. It is united with three following auxiliary lobes into a suspensive lobe, which is sloping so strongly that its inner termination exceeds the level of the siphonal lobe.

The extreme ramification and the narrow stems of the saddles together with the sloping suspensive lobe are distinctive features of this sutural line. In my smaller type-specimen the general arrangement only of the sutures is clearly seen, the ramification being developed less strongly, according to its less advanced stage of growth. Details are shown in the siphonal lobe only, which is richly serrated.

A short notice of these two specimens has been published by Uhlig, who emphasized the necessity of awaiting fresh discoveries for defining this interesting species more accurately. Nevertheless the distinctive features are, in my opinion, sufficiently well marked to justify the introduction of a new species, for which the name *Perisphinctes Dacquei* is here proposed.

The importance of *P. Dacquei* is evident from its isolated position among the Ammonites of the Spiti shales. The innermost whorls somewhat resemble the group of *P. torquatus* in the curvature of ribs and in the presence of rounded flanks, but even in this stage of growth considerable differences exist in the shape

of the transverse section and in the sutures. In more advanced stages of development the independent character of our species is marked, especially by its bulky shape, low cross-section and the strongly serrated sutures.

If we look out for species allied to the present one more closely, *Perisphinctes Beyrichii* Futterer[59] from the Upper Jurassic rocks of Mombasa must be taken into consideration. There are some differences in the development of the sutures. In the adolescent stage the sutures of *P. Dacquei* agree pretty well with those of *P. Beyrichii* as illustrated by Futterer in Plate II, fig. 2, but in old age the latter form is radically distinguished by a remarkable reduction and a smaller amount of ramification (compare Futterer, Plate II, fig. 3). In *P. Dacquei*, on the contrary, all the elements of the sutural line are developed and serrated more strongly in large-sized specimens. In its involution and cross-section *P. Beyrichii* resembles our new species, but in the latter the transverse section is depressed still more strongly. Special mention must be made here of Dacqué's description of *P. Beyrichii*.[60] Dacqué, to whom Futterer's type-specimens were known, remarks that equally sized examples among them were distinguished from his own types by cross-sections depressed more strongly, but increasing in height more rapidly in proportion, according to their advancement in growth. This character, which has not been mentioned by Futterer, is of some importance for a discussion of the relationship with our species, in full-grown examples of *P. Beyrichii* a difference in the shape of the cross-section being added to the difference in the sutures This difference is clearly evident from our large fragment, the whorls of which are depressed quite as strongly as in the smaller example.

Among the species of *Perisphinctes* from Mombasa there is one with a sutural line agreeing exactly with the sutures of our large specimen. It has been illustrated by Futterer[61] and referred to a form allied very closely to *P. Beyrichii*, but known to him very incompletely in the shape of large fragments only. It is possible that with more abundant material at hand for comparison this form might prove to be specifically identical with the species from the Spiti shales. For the present a more definite opinion regarding this question must be postponed.

In size and cross-section our new species agrees equally well with *Perisphinctes bathyplocus* Waagen.[62] The distinguishing features are the following: *P. bathyplocus* is more evolute, has simpler sutures, the branching points of the ribs are situated higher, and the secondary ribs, which are nearly radial, are diverging more strongly. A very close relationship between *P. Dacquei* and *P. bathyplocus* cannot, therefore, be advocated. Notwithstanding the similarity of the cross-section the general shape does not agree sufficiently to permit the establishment of a near affinity.

[59] Beitraege zur Kenntnis des Jura in Ostafrika, *Zeitschr. Deutsch. Geol. Ges.*, Bd. XLVI, p. 9, Taf. II.

[60] Dogger und Malm aus Ostafrika, *Beitr. z. Geol. u. Palaeontol. Oesterr.-Ungarns, etc.* XXIII, 1910, p. 14, Taf. IV, fig. 2.

[61] *Ibidem*, Taf VI, fig. 2.

[62] Jurassic fauna of Kutch. I, Cephalopoda, *Palaeontol. Ind.*, ser. IX, Vol. I, Pl. XLVII, p. 185.

A species identical with *Perisphinctes bathyplocus* Waagen has bee de scribed recently from Madagascar by P. Lemoine.[63] I cannot agree, however, wit a that author in the identification of the species from Kutch with *P Beyrichii* Futt. In spite of their similarity, which has been mentioned repeatedly, slight differences in the sutures, involution and ornamentation render a direct identity unfeasible. Unfortunately, Lemoine has not given any illustration of the sutures of h s specimen from Madagascar. This is to be regretted so much the more, because in Waagen's Indian specimens the sutures have been preserved incompletely. In his description Lemoine states the absence of dichotomous ribs, but this is certainly due to a mistake only, his illustration showing distinctly both undivided and dichotomous ribs. In its bulky shape Lemoine's form resembles *P. Dacquei* as closely as Waagen's species from Kutch.

A species which deserves special mention on account of its close rela tionship to our Himalayan form, is *Perisphinctes indogermanus* Waagen.[64] It exhibits the same arrangement of the sutural line, with a suspensive lobe sloping very strongly and with lobes and saddles richly ramified Notwithstanding its large dimensions Waagen's type-specimen consists of air-chambers only, has the cross-section strongly depressed and is provided w'th deep constrictions. In all those features it agrees closely with *P. Dacquei.* Nevertheless the two species are easily distinguishable. *P. indogermanus* is more evolute, the flanks are rounded more strongly, the ornamentation is more irregular, with many single ribs and intercalated costæ. If we consider the young individual, which has been referred to *P. indogermanus* by Waagen, as a representative of this species, its mode of development must differ considerably from that noticed in our Himalayan form, the inner whorls of the species from Kutch possessing a rounded lumen in the adolescent stage of growth. There can be no question, consequently, of an identity of *Perisphinctes indogermanus* and *P. Dacquei*, although a de tailed comparison shows unmistakably that there is a close relationship between them.

Perisphinctes indogermanus Waag. belongs to the group of *P. plicatilis.* It is only in this group of *Perisphinctes* that we find the arrangement of the sutures characteristic of our H malayan species. Thus the sutures of *Perisphinctes promiscuus* Bukowski,[65] which has been considered by Bukowski to be a very close relation of *P indogermanus,* show a nearly radial, sloping suspensive lobe of considerable depth and a rich ram fication. The same remark appl es to the sutures of *P Martelli* Opp. and *P. chloroolithicus,* which have been figured b Siemiradzki.[66]

[63] Ammonites d Jurassique supér d. cercle d'Analalava, *Annales de Paléontologie,* V, Paris, 910 p. 42, Pl. VIII, fig. 10.

[64] Jurassic fauna of Kutch, *l.c.*, p. 185, Pl. XLVII, fig. I.

[65] Ueber die Jurabildungen von Czenstochau in P len, *Beitraege z. Palaeontol. Oesterr. Ungarns, etc.*, V, 1887, p. 137, Taf. XXIX.

[66] Monograph. Bescreib d. Ammonitengattung Perisphinctes, *Palæontographica,* XLV, pp 262, 268.

It is permissible to regard *Perisphinctes africanus* Dacqué [67] as a species nearly allied to the group of *P. promiscuus*. It has been placed in that group by Dacqué on account of the arrangement of its sutures. Its lobes, it is true, are narrower than in our species, but among the rich materials from Mombasa there is a second form, which in this respect agrees with *P. Dacquei* more closely. *Perisphinctes Pagri* Waagen,[68] on the other hand, agrees with our species in the shape of the cross section only. That the supposition of a near relationship between the two is erroneous, need therefore hardly be emphasized.

According to Uhlig,[69] the representatives of the group of *Perisphinctes biplex-plicatilis* exhibit a sutural line similar to that of *Virgatosphinctes*. In my opinion a difference might be found in the shape of the suspensive lobe. This lobe is never as deep in *Virgatosphinctes* as in the former group. It scarcely reaches the depth of the siphonal lobe, and even that in very few forms only, being, as a rule, considerably shorter and never directed quite radially. Just this difference is also noticed between the sutures of the *plicatilis* group and *P. Beyrichii*, which has been placed correctly in *Virgatosphinctes* by Dacqué. *Perisphinctes Dacquei*, however, cannot be grouped with this sub-genus. Such a grouping is contradicted not only by the differences in the arrangement of the sutural line, but also by the rarity of virgatotomous ribs, even in my largest specimen. The foregoing differences, when considered as a whole, seem to justify a more natural classification of our species among the group of *Perisphinctes plicatilis*.

Locality, number of specimens examined.—Two specimens from Shangra, Gnari-Khorsum coll. Schlagintweit

Perisphinctes Dieneri nov. sp.

(Plate CIII, fig. 1 *a*, *b*)

Dimensions:—

2r	70 mm.	1
w	27 „	0·38
h_1	26 „	0·37
h_2	19 „	0·27
a	26 „	0·37

Shell moderately involute, with a deep umbilicus, which is surrounded by a steep wall. Umbilical margin distinctly marked. Lateral parts flat, passing gradually into the rounded siphonal area. Greatest transverse diameter corresponding with the umbilical margin. Last volution belonging to the body-chamber, but the peristome has not been preserved. Actual length of the body-chamber unknown.

The ornamentation consists of numerous, closely crowed, sharp ribs, which originate in the umbilical margin and cross the lateral parts in a slightly forward

[67] *l.c.*, p. 17, P. III, fig. 2.
[68] *l.c.* p. 181, Pl. XLVII.
[69] *l.c.*, p. 311.

turned direction, without being deflected backward in the umbilical region. They bifurcate in the middle of the flanks and pass across the siphonal area in a shallow curve. Together with these dichotomising ribs undivided main ribs occur, whose number increases rapidly in the direction towards the aperture. At the beginning of the last volution one undivided rib is counted to eight dichotomous ones, but in the vicinity of the aperture the number of dichotomous and undivided ribs is nearly equal.

Sixty main ribs are counted on the flanks of the last whorl but 106 ribs in the siphonal region. A siphonal furrow and constrictions are entirely absent. The sculpture of the inner nucleus is comparatively strong. The transverse section of the inner whorls is considerably broader than high. No external furrow has been noticed, even in volutions attaining a diameter of 2 mm.

In *Aulacosphinctes divergens nov. sp.* a sculpture of the body-chamber has been described, which is conspicuous for the increasing number of undivided ribs in the direction towards the aperture. This character of ornamentation is still more prominent in the present species. A third form with the same tendency of sculpture prevailing in the body-chamber will be described later on. There can be no doubt about the intimate relationship between the last species and *Perisphinctes Dieneri*, but a problem of considerable difficulty is offered by *P.* (*Aulacosphinctes*) *divergens*. It differs from our species by the smaller number of undivided ribs, by a lesser density of its sculpture and by a wider umbilicus, all those features imparting to it a general shape, which differs sufficiently from *P. Dieneri* to preclude the two species being united in the same group. The frequency of undivided ribs is no sufficient reason for establishing their closer relationship. It is a character found in different groups of *Perisphinctes* and therefore no argument in favour of a direct affinity.

In involution, transverse section and density of ribs *Perisphinctes Dieneri* strongly resembles *P. denseplicatus* Waagen[70] from Kutch, which has been discovered among the Ammonites of the Spiti shales by Uhlig.[71] There is, however, no agreement in the tendency of ornamentation. Inner whorls of *P. denseplicatus* often show undivided ribs, but in later stages of growth this species becomes a typical representative of the sub-genus *Virgatosphinctes*, whose sculpture consists exclusively of dichotomous and trichotomous ribs. This is just the reverse of the development noticed in our species in which undivided ribs are very rare in the inner volutions and rapidly increase in number in the body-chamber volution, whereas they are restricted to the inner nucleus in *P. denseplicatus*.

Uhlig's specimens from the Spiti shales agree with our form in the shape of the cross-section. Waagen's types are higher and narrower. They are compressed in immature stages, in later stages of growth their width increases more rapidly than the height. This is just the reverse of what has been noticed in Uhlig's types from the Spiti shales and in *P. Dieneri*, which have proportionately

[70] *l.c.*, p. 301, Pl. XLVI.
[71] *l.c.*, p. 313, Pl. LIII, fig. 3

broader and lower volutions in immature examples, but a transverse section of equal height and width or even compressed whorls in the full-grown stage.

Uhlig himself did not attribute any deeper significance to those differences, which were well known to him, the Himalayan specimens themselves, although unquestionably belonging to a single species, being subject to considerable variations. "If the differences in the structure of the lobes and the form of the shell," he remarks, "were distributed according to a definite law, it might be possible to distinguish two species. But failing this condition together with the fact that the most pronounced differences affect precisely specimens all derived from one locality, we are evidently justified in uniting these various forms into one species."

A second species, which must be taken into consideration for closer comparison, is *Virgatosphinctes serpentinus* Uhlig.[72] The typical form of *P. serpentinus*, as it has been illustrated by Uhlig, differs considerably from *P. Dieneri*, having very few undivided ribs and trichotomous costæ accompanying the constrictions. It is in the meantime more evolute. But in the Palæontological Museum of Munich I had an opportunity of studying a specimen which had been identified with *P. serpentinus* by Uhlig. This specimen agrees with the present form in the majority of essential characters, if we except the pattern of bifurcation of the ribs. There is a remarkable resemblance in the general shape and involution. The number of undivided ribs is considerably larger than in the typical form of *P. serpentinus*, but together with them virgatotomous ribs, as they are characteristic of the sub-genus *Virgatosphinctes*, are noticed repeatedly. Here, as in so many cases, the question arises whether or not a specific importance should be attributed to such differences in ornamentation. In my opinion differences of this kind ought not to be neglected, bearing in mind the fact that a form agreeing with *P. Dieneri* could not be looked for among typical representatives of *P. serpentinus* and that the species in the Museum of Munich is also distinguished by some other details of minor importance. In Uhlig's description of the Spiti Ammonites a very circumscribed definition of the single species has been adopted. In accordance with this illustrious author I am obliged to retain his interpretation and must consequently refrain from an identification of the two species.

There is no need for a closer comparison of *P. Dieneri* with other species from the Spiti shales.

Among European types of *Perisphinctes* the group of *P. Lucingensis* Favre from the Oxford stage resembles our species most closely in the pattern of sculpture. *P. Jeremejevi* Nikitin,[73] which has been united with *P. Lucingensis* by Siemiradzki, exhibits the same tendency of development in the density of ribs,

[72] *l.c.*, p. 322, Pl. LII.

[73] Cephalopodenfauna der Jurabildungen des Gouvern. Kostroma, *Verhandl. kais. Russ. Mineral. Ges.*, St. Petersburg, 1884 p. 38 Taf. IV, fig. 16.

the frequency of undivided costæ and their increase in number, according to the development of growth. A similar remark applies to the typical *P. Lucingensis* Favre[74] and to several nearly allied forms. But on the other hand the group differs from *P. Dieneri* by its involution and by a higher and narrower transverse section. The bifurcation of the ribs is shifted closer to the siphonal part. Nor can we overlook Siemiradzki's[75] note on the discovery of a body-chamber of *P. Lucingensis* with virgatotomous ribs. The similarity of sculpture appears to me no sufficient reason for assuming a direct affinity of *P. Dieneri* with the group of *P. Lucingensis*, their habitat being separated by enormous distances.

Among other similar forms *Perisphinctes densestriatus* Steuer [76] may be mentioned, with a bifurcation of ribs, which is described as being less prominent in immature stages and in the vicinity of the body-chamber of full-grown individuals. Whether undivided or short intercalated ribs have been meant in this description by Steuer is neither evident from his illustration nor from Behrendsen's text.[77]

Several species reminding us of the group of *P. Lucingensis* have been illustrated by A. d. Riaz.[78] *Aulacosphinctes transitorius* Zittel agrees with *P. Dieneri* in the shape of its cross-section, but differs by its involution, by the absence of undivided ribs and by the development of an external furrow. I need not enumerate here every single form of *Perisphinctes* in which an alteration of undivided and bifurcating ribs occurs. A considerable number of such is known (*P. Pavlovi* Steu., *P natricoides* Uhl., etc.). The majority are evolute, not densely ribbed, and of small height. There exists certainly no near affinity between them and our Himalayan species.

According to our present state of knowledge we might be induced to consider a grouping of *P. Dieneri* with *P. denseplicatus* more natural than any other classification. But special stress must be laid on the fact that in the tendency to simplify their ornamentation neither *P. Dieneri* nor *P. alternecostatus* approach any form of the group of *P. denseplicatus*. Nor can those two species be placed with certainty into any of the sub-genera which have been established by Uhlig for the accommodation of the *Perisphinctes* from the Spiti shales. From *Aulacosphinctes* they are distinguished by the absence of an external furrow, and by the considerable amount of involution, from *Virgatosphinctes* by the opposite tendency in the development of their ornamentation. Much more abundant material will be needed before we are able to fix the true systematic position within the genus *Perisphinctes*.

Locality, number of specimens examined.—*Perisphinctes Dieneri* is represented by a well preserved specimen and by a fragment from the Chidamu beds of Chidamu, coll. Diener.

[74] Déscription des fossiles du terrain Jurassique do la montagne des Voirons, *Mém. Soc. Paléontolog. Suisse*, Genève, II. 1875, p. 32, Pl. III.

[75] Monogr. Beschreib. d. Ammonitengat. Perisphinctes, *Palæontographica*, XLV, p. 271.

[76] Argentinische Juraablagerungen, *Palaeontol. Abhandlungen v. Dames u. Kayser*, VII, p. 62, Taf. XV, figs. 8—10.

[77] *Zeitschr. Deutsch. Geol. Ges.*, 1891, Bd. XLIII, Description of *Perisphinctes virgulatus*, p. 409.

[78] Déscription des Ammonites des couches à Peltoceras transversarium de Trept, 1898.

PERISPHINCTES ALTERNECOSTATUS nov. sp.

(Plate CIV, fig. 1 *a*, *b*.)

Dimensions:—

2r	59 mm..	1	
w	26 „	0·44	
h_1	20 „	0·34	
h_2	15 „	0·25	
d	23 „	0·39	(Exact measurements not available.)

A cast with a deep umbilicus and whorls enveloping one another to one-half their height. Umbilical wall oblique and passing gradually into the lateral parts, which are flattened and not separated distinctly from the gently curved siphonal area. Cross-section trapezoidal, with rounded-off corners. Its greatest transverse diameter corresponds to the umbilical margin. Body-chamber long, comprising one entire and one half volution, without traces of the actual peristome being yet present. Largest diameter of my type-specimen ab. 70 mm. The above measurements have been taken from a place situated one-quarter of a volution behind the aperture.

Sculpture consisting of densely crowded, sharp ribs, which originate in the umbilical wall and pass across the lateral and siphonal parts in a forward turned direction. One-half of the ribs dichotomise below the middle of the flanks, the second half remains undivided. Occasionally one dichotomous or one undivided rib is followed immediately by a rib of the same character. In the vicinity of the aperture of our example the ribs show a distinctly backward turned deflection along the umbilical wall. In the meantime the branching point of the ribs is shifted to the lower third of the lateral parts. This ornamentation of the full-grown individual, consisting of dense alternating ribs, can be traced to a diameter of the shell of ab. 18 mm., the branching points of the ribs remaining invariably visible within the umbilicus. In volutions of the inner nucleus corresponding to a diameter of 10 mm., the ribs are exclusively dichotomous and very delicate, the transverse section is considerably broader than high the siphonal area devoid of any external furrow.

In the last volution 64 main ribs have been counted, and 49 in the penultimate one. A shallow constriction has been noticed in the last whorl. The extraordinary length of the body-chamber renders an examination of the sutures impossible.

From *Perisphinctes Dieneri*, *P. alternecostatus* differs by a wider umbilicus, smaller height of the cross-section, by the absence of a distinct demarcation between the lateral parts and the umbilical wall, by the deeper position of the branching points of the ribs and by the persistency of undivided ribs in adolescent stages of growth. They agree, however, in the general shape of the shell and cross-section, in the density of ribs, in the sculpture of the last volution and probably also in the length of the body-chamber. Both species are un-

doubtedly closely allied, although there is no question of an identity. It is possible, however, that with more abundant material at hand transitional shapes might be found. For the present we must consider *P. alternecostatus* as a species really distinct from *P. Dieneri*.

The affinities with other types of the Spiti shales have been treated in my notes on the relationship of *P. Dieneri* with *P. denseplicatus* Waag. *P. alternecostatus* differs from Waagen's species not only by its ornamentation, but also by its involution. If future researches should lead to the discovery of a closer affinity between *P. Dieneri* and *P. denseplicatus*, *P. alternecostatus* would certainly have to be placed at a further distance from Waagen's species.

From *Aulacosphinctes divergens* our species is distinguished by its denser ribbing and by the persistency of single ribs in the immature stage. *Virgatosphinctes serpentinus* Uhlig[79] agrees with our form in involution, shape of the cross-section and density of ribs, but shows very few undivided ribs only. On the other hand it is provided with numerous constrictions, which are accompanied by trichotomous ribs, whereas in our species the single constriction which has been noticed is followed by a change in the sculpture leading to the development of free intercalated ribs.

In density of ribs and in the pattern of ornamentation there is some similarity with *Aulacosphinctes linoptychus* Uhlig,[80] but this is a species of small size, the peristome having been preserved in Uhlig's type-specimen, which is provided with a different cross-section and with a deep external furrow. Its similarity with *P. natricoides* Uhl. and *P. tibetanus* Uhl. is still more distant.

In the fauna of Kutch *Perisphinctes alterneplicatus* Waagen[81] shows an ornamentation consisting of alternating divided and single ribs, but differs by its wider umbilicus, a smaller number of ribs, a higher position of their branching points and by a higher cross-section. Nevertheless it is not impossible that future researches might lead to establishing a closer affinity with this species from the Katrol sandstone.

Among European species of *Perisphinctes* there is none which might put in a claim for closer comparison. The distant affinities with the group of *P. Lucingensis* have been treated in the description of *P. Dieneri*. *Perisphinctes trichoplocus* Gemmellaro[82] reminds us of the present species in its measurements and in the development of both single and divided ribs, but the cross-section is more strongly compressed, the ribs are more delicate and the branching points are situated at higher levels.

As regards the classification of our species among the sub-genera of *Perisphinctes*, the reader is referred to the respective notes on *P. Dieneri*.

Locality, number of specimens examined.—One specimen from the Schlagintweit collection, without the locality being indicated.

[79] *l.c.*, p. 322, Pl. II, fig. 2.

[80] *l.c.*, p. 357, Pl. XLII, fig. 4.

[81] *l.c.*, p. 163, Pl. XX, fig. 13.

[82] Sopra alcune faune Giuresi e liasiche della Sicilia, *Estr. del giorn. d. scienze nat. e econ. Catania*, 1872-82, p. 163, Pl. XX, fig. 13.

B.—BRACHIOPODA.

Fam. RHYNCHONELLIDÆ Gray.

Gen. RHYNCHONELLA Fisch.

Group of RHYNCHONELLA LACUNOSA Quenst.

Among the *Rhynchonellæ* entrusted to me for examination a very large percentage belongs to this group, although no direct identification with any of the species hitherto described could be attempted. On the other hand my scanty materials and the indifferent state of preservation do not enable me to define the distinctive features of my Himalayan forms more accurately and thus oblige me to include them in the group of *Rh. lacunosa* without introducing new specific denominations.

All the forms belonging to the group of *Rh. lacunosa* vary within wide limits. It is consequently very difficult to select a prototype for each single variety. As has been noticed by Suess[83] and Quenstedt,[84] the beak is never provided with sharp edges in this group. This is evident from an examination of the type-specimens of *Rh. Hoheneggeri* and *Rh. subsimilis*[85] from Stramberg. But those type-specimens are all provided with their original shelly test. The examples from the Spiti shales, on the contrary, are as a rule casts. Among the few examples, in which the shelly test has been preserved, there is one in which the sharp edges of the beak, which are noticed in the cast, actually disappear as soon as the cast is covered by the shelly substance. But two other specimens of smaller size are provided with a shelly test, in which those edges bordering the beak are marked as distinctly as in the cast. My materials are too scanty to permit a closer investigation, but to me a specific separation between the smaller and larger examples appears impossible. Perhaps the edges bordering the beak become obliterated gradually in more advanced stages of growth.

The most important varieties of the *lacunosa* group are *Rhynchonella lacunosa, arolica, sparsicosta, Suessi*. The last named variety has been described very carefully and defined distinctly by Suess. Its relationship with my Himalayan forms is very distant only. Considerable differences of opinion prevail regarding the definition of the other varieties. In accordance with H. Haas[86] I consider Quenstedt's illustration of *Rh. lacunosa* as representing the prototype of that variety, all previous illustrations being neither satisfactory nor representing specimens, whose stratigraphical horizon has been fixed with sufficient accuracy.

[83] Die Brachiopoden der Stramberger Schichten, *Hauer's Beitraege zur Palaeontographie*, I, 1858, p. 53.

[84] Petrefaktenkunde Deutschlands, Brachiopoden. Leipzig, 1871, p. 121.

[85] *Rh. Suessi* Zittel, Die Fauna der älteren, Cephalopoden führenden Tithonbildungen, *Mitt. aus d. Museum d. kgl. Bayr. Staates*, München, 1868, p. 11.

[86] Die Brachiopoden der Juraformation von Elsass-Lothringen, *Abhandl. Geol. Spezialkarte v. Elsass-Lothr.*, 1882; Beiträge z. Kenntn. d. jurassischen Brachiopodenfauna der Schweiz, etc., *Abhandl. Schweiz. Palaeontol. Ges.*, Bd. XVII, 1890, p. 37.

The *var. arolica* not having been figured by Oppel, we must consequently rely on the description and illustration of this form, which has been given by Moesch.[87] Notwithstanding a large number of investigations into the affinities of *Rh. lacunosa* and *Rh. arolica* an exact definition of the types and their distinctive features is still missing. Haas figured a large series of transitional forms, connecting the two varieties, but has not fixed the characters of difference noticed between the types. Such types must be fixed, however, as terminal members of a series of forms, whose close inter-relationship has to find its outward expression in a simplification of nomenclature. As far as it is necessary for a comparison of our Himalayan examples, I shall attempt to arrive at a definition of those types from the rich literature on this subject.

Rh. arolica is distinguished by the following characters from *Rh. lacunosa*, according to Moesch. The beak is less slender, the wings are flatter and more attenuated, the valves vaulted less strongly, the ribs reach from the very apex as far as the front margin. On the two last named differences we cannot rely. The curvature of the valves is subject to considerable variation, the ribs also sometimes reach from the front to the very apex in *Rh. lacunosa*, types with shorter ribs representing the variety *sparsicosta*. The more obtuse beak and the attenuated wings are good characters of the typical *Rh. lacunosa*. The remarkable divergency of median and lateral ribs might be added. This divergency begins to be prominent in the apex, the median and lateral ribs, leaving a smooth area free between them. It is accompanied by a more narrow but deeper and, on the whole, more distinctly developed sinus. The shell of *Rh. lacunosa* is nearly always asymmetrical. The ribbing in *Rh. arolica* is never as dense as in typical specimens of *Rh. lacunosa*.

An attempt to group the examples illustrated by Haas leads to the following results. All the examples illustrated on Plate VI, figs. 1—8, belong to *Rh. lacunosa*, those on Plate III to *Rh. arolica*. Among the figures represented on Plate IV, figs. 1—5, are typical shapes of *Rh. arolica*, figs. 6—9 transitional shapes. On Plate V typical specimens only are seen, whereas Haas is inclined to refer them to *Rh. arolica*.

The varietal independence of *Rh. sparsicosta*[88] has often been doubted, although it can be distinguished both from *Rh. lacunosa* and *Rh. arolica* by its shorter ribs, which never reach the apex. Its occurrence in the Stramberg limestone has been denied by Zittel,* who proved the identity of the forms referred erroneously to *Rh. sparsicosta*, with *Rh. Malbosi* Pictet.[89] The latter species is easily distinguished from *Rh. lacunosa* on account of its lower beak, its symmetrical structure and the two valves being equally vaulted. It belongs to a different stratigraphical horizon.

[87] Der Aargauer Jura u. d. noerdliche Gebiet des Kantons Zürich, *Beitr. z. Geol. Karte d. Schweiz*, IV, 1867, p. 311, Taf. VI, fig. 9.

[88] Quenstedt. Der Jura, 1858. p. 633, Taf. 78, figs. 19—22.

*l.c.. p. 11.

[89] Melanges paléontologiques, Genève, p. 111, Pl. XXVI, fig. 10

RHYNCHONELLA aff. LACUNOSA Quenst.

(Plate CIV, figs. 3—5.)

Quenstedt, Jura, 1858. p. 634. Taf. 78, figs. 15, 16.
Quenstedt, Petrefaktenkunde, Brachiopoden, p. 121, Taf. 39, f. 72.
E. de Loriol. Monographie des couches de la zone à Ammonites tenuilobatus de Baden, *Mém. Soc. Paléontol. de la Suisse*, III—V, 1876-78, p. 186, Pl. XXIII, figs. 39, 40, *non* 38.
Haas, Beiträge z. Kenntn. d. jurass. Brachiopodenfauna d. Schweiz, *l.c.*, p. 43, Taf. VI.

All my specimens are moderately globose, a little broader than high, the largest among them attaining 24 mm. in width. Ventral valve always considerably flatter than the dorsal one. The dorsal valve is curved slowly and reaches its maximum thickness in the lower half of the shell, being turned back from this place somewhat towards the front margin. Median fold rather prominent. Sinus of the ventral valve originating in the middle of the length and increasing in depth gradually in the direction towards the front. The beak has not been preserved in any of my specimens. Cardinal angle obtuse. There are always distinct edges bordering the beak developed in the cast. The line, in which the two valves meet along the front, is curved somewhat towards the dorsal valve. In the smaller valve a median septum is invariably present.

In the majority of examples the surface of the dorsal valve is covered with 11 to 13 ribs, which are broadly and evenly rounded both on the shell and the cast. Three ribs are confined to the mesial fold; they are remarkably broad and of equal length, and corresponding with two ribs in the opposite valve. Of lateral ribs 3 to 5 are present on either side. They do not diverge from the median ribs considerably, the divergency being restricted to the lower portion of the shell. Intercalated ribs are entirely absent. Both in the shell and cast all ribs nearly attain the very apex, occupying at least four-fifths of the height of the valves. Exceptionally, shapes have been noticed with four ribs occupying the dorsal fold. In this case two of them may originate from the bifurcation of a single main rib in the middle of its length. Striæ of growth are occasionally developed. In both valves a concentric line is clearly seen in the vicinity of the apex.

The present form agrees in some of its characters with *Rhynchonella lacunosa*, in others with *Rh. arolica*. It resembles *Rh. lacunosa* in its shape, in the small amount of divergency of median and lateral ribs, in its symmetrical structure. In *Rh. lacunosa*, however, those characters are united with a shallow broad sinus, as we may see from the illustrations given by Haas[90] and Quenstedt, and with a dense ribbing, whereas our Himalayan examples are distinguished by coarse ribs and a deeper sinus. In both of those characters they remind us of *Rh. arolica*, although they show less similarity with that species in their general shape. Among all the illustrations published by Haas fig. 1 on Plate V approaches most nearly my larger, fig. 11 my smaller examples. They are consequently connected closely with transitional shapes of the European varieties.

The majority of illustrations, which have been published by other authors, are not sufficient for closer comparison. This remark applies especially

[90] *l.c.*, Taf. VI, figs. 1—3.

to the memoir of A. Castillo and I. G. Aguilera,[91] who have figured a large number of forms resembling our shapes from the Spiti shales in their general features But it is impossible to arrive at a conclusion regarding their systematic position without an examination of frontal and lateral views, which are, unfortunately, missing in the monograph quoted above.

Rhynchonella arolica Favre[92] resembles our species in many respects, but is wider and has the lateral ribs curved more strongly.

In my opinion the shapes from the Spiti shales belong probably to a new species, but their state of preservation is too unsatisfactory to justify the introduction of a new name

Locality, number of specimens examined—Jandu, Sherik river, Niti pass, Sirkia, Shalshal (Chidamu beds), Ting Jung la. Altogether 18 specimens, 15 of them from the collection of the Geological Survey of India, the rest from the coll. Schlagintweit, Palæontological Museum, Munich.

In Europe *Rhynchonella lacunosa* is restricted to the Malm β—δ.

Rhynchonella sp. aff. sparsicosta Quenst.

(Plate CIV, fig. 6)

Haas, Jurass. Brachiopodenfauna d. Schweiz, etc., *Abhandl. Schweizer Palaeontol. Ges.*, *l.c.*, p. 51 Taf. VI. For a list of synonyms this memoir should be consulted.

To the above species a number of small *Rhynchonellæ* is associated, which are referred provisionally and with a query to the *var. sparsicosta* Quenst. From the preceding species they differ by their coarse ribs, which do not reach beyond the middle of the length of the shell, the larger portion of which consequently remains smooth. One of my specimens is remarkably globose and its dorsal fold is provided with two ribs only The divergency of the ribs in the fold and wings exceeds that noticed in the preceding variety. It is easy to distinguish the representatives of those two varieties among my Himalayan materials, but the possibility of finding transitional shapes with a larger number of individuals at hand cannot be denied. A fact which speaks rather strongly in favour of a specific separation is the existence of several examples of small size, which nevertheless belong undoubtedly to *Rh. aff lacunosa*.

It is worth mentioning that the present specimens resemble very closely some forms of the group of *Rh. variabilis*, as described from the Lias by Davidson and others. This is another fact to be added to the numerous reasons for the small stratigraphical value of *Rhynchonellæ*. There is also a certain similarity with *Rh. pouciplicata* Kitchin[93] in the shape of the coarse ribs, but in the species from Kutch the valves are more bulky and the sculpture is even coarser.

Locality, number of specimens examined. Niti pass, 7 specimens.

[91] Fauna fossil. d. l. Sierra de Catorce San Luis Potosi *Bol. Com. Geol Mexico*, I, 1895, Pl. I.

[92] La zone à Ammonites acanthicus es Alpes de la Suisse, Mém. Soc Paléontol. Suisse, IV, 1878, p 76, Pl. IX, fig. 8.

[93] Jurassic fauna of Kutch. Vol III, Pt I, Brachiopoda, *Palæont ind* ser. IX, 1900, p 70, Pl. V, figs 4, 5.

The European examples of the *var. sparsicosta* have been quoted from the zone of *Oppelia tenuilobata* of Baden and from the Malm α and γ of Suabia.

Rhynchonella aff. Hoheneggeri Suess.

(Plate CII, fig. 4 *a—d.*)

1859. Suess, Die Brachiopoden der Stramberger Schichten, *Hauer's Beitraege z. Palaeontographie*, I, p. 56, Taf. VI, figs. 13—19.

1861. Ooster, Synopsis des Brachiopodes Suisses, Pétrifications des Alpes Suisses, p. 52, Pl. XVII.

1871. Quenstedt, Brachiopoden, p. 128, Taf. XL, figs. 4, 5 (*Rh. rupicalcis*, non *Hoheneggeri* Zittel, Haas, etc.).

This is a small species, broader than long, with a dorsal value vaulted more strongly. Greatest transverse diameter corresponding with the front region. The dorsal valve is provided with six ribs, two of them stronger and restricted to the median fold. Ribs not seen distinctly in the apical region, where the shell has been slightly injured by weathering. Ventral value with a deep sinus, which is bordered by two extremely strong ribs. Two more ribs follow on the wings on either side. The sinus is divided by a delicate median rib. Whether or not this mesial rib reaches the apex could not be ascertained. Only one side of the sharp and slender beak has been preserved. It is not bordered by edges.

The only specimen available for examination has been preserved as a cast only.

The type-specimens of *Rhynchonella Hoheneggeri* Suess, which are before me, resemble our Himalayan specimen very closely, especially so in the shape of the beak and in their ornamentation. The most important feature in *Rh. Hoheneggeri*—the strong development of the lateral ribs bordering the sinus of the ventral valve—is also present in our Himalayan form. Another character of ornamentation, which the two species have in common, is the strength of the first lateral rib in the dorsal valve, which is less prominent than the ribs covering the mesial fold. But on the other hand the Alpine types are more irregular. The ribs are often bifurcating and developed unequally. The section of the dorsal valve in the form from the Spiti shales is rounded less evenly, although this difference is perhaps due to accidental causes (irregular weathering). Among the illustrations published by Suess, fig. 14 reminds us of our Himalayan specimen most strongly.

Rhynchonella Hoheneggeri is a very well defined species, and the identity of the Alpine and Himalayan form could be easily decided with richer and more complete materials at hand for comparison. There is, however, no great probability of a direct identity, and for the moment it is certainly more safe to consider them as types very nearly allied. Among European *Rhynchonellæ* Quenstedt's type, which has been quoted above, is undoubtedly identical with the Alpine types described by Suess, as I am able to state from a comparison of the type-specimens from Stramberg. An identification of the form referred to *Rh. Hoheneggeri* by

Haas is questionable. Among the *Rhynchonellæ* illustrated by this author,[94] those grouped on Plate IX, figs. 9—13, agree with the types from Stramberg in their sculpture, but the equal convexity of both valves and the obtuse beak are characters of difference, suggestive of a very near relationship but not of an actual identity of the two forms. A species, which has been united with *Rh. Hoheneggeri* by Haas, but to which an independent position must be accorded, is *Rhynchonella Malbosi* Pictet.[95] It is distinguished from *Rh. Hoheneggeri* by its obtuse beak and more regular ribbing. The distinctive features are sufficiently evident from the illustrations, but still more prominent in the type-specimens themselves. Nor can the examples referred to *Rh. Hoheneggeri* by Zittel[96] be left with the species as interpreted by Suess.

I am following Suess in placing *Rh. Hoheneggeri* in the group of *Rh. lacunosa.*

Locality, number of specimens examined.—Jandu, Sherik river, one specimen, coll. Griesbach.

The European *Rhynchonella Hoheneggeri* has been quoted from the lower Tithonian stage (limestone of Nesselsdorf).

Group of Rhynchonella trilobata Zieten.

Rhynchonella aff. Moeschi Haas.

(Plate CIV, fig. 7 *a—d.*)

Rhynchonella varians (Schloth.) Stoliczka, Geological sections across the Himalaya Mts., etc., Mem. Geol. Surv of India, V, 1865, p. 87 (pp.).

Rh. trilobata var. Moeschi Haas, Jurass. Brachiopodenf. d. Schweiz, Abhandl. Schweiz. Palaeontol. Ges., *l.c.*, p. 58, Taf. VII, figs. 7—9, VIII, figs. 1. 2.

Rh. trilobata var. Moeschi Greppin, Fossiles d'Oberbuchsiten, p. 98, Pl. VIII, figs. 3, 4.

Shell broader thar long. Ventral valve flattened, with a prominent sinus, cardinal angle equal to a right one. Beak elevated ab. 3 mm. above the cardinal hinge, not curved, provided with a sharp point. Margin of the beak perfectly straight, without bordering edges. Deltidium high and narrow, foramen not visible. Dorsal valve vaulted very strongly. Its greatest transverse diameter corresponds to the vicinity of the front, but from this place its convexity is sloping somewhat towards the front line. The produced front imparts a feeble trilobate character to this species.

Ribs narrow and sharp. Eighteen ribs are counted on each valve, five of them in the dorsal median fold and four in the corresponding ventral sinus. They are not arranged along a straight line, but are also noticed on the slopes of the mesial fold. In the ventral valve they reach as far as the terminal apex, but in

[94] Monographie des Brachiopodes rhét. et jurass. des Alpes Vaudoises, *Mém. Soc. Paléont. Suisse*, XI, 1885, XIII, 1887.

[95] Melanges paléontol. II. Faune a Terebratula diphyoides, IV. Fossiles de la Porte de France, Genève, 167, 168. p 11, Pl XXVI, fig. 10; Favre, Description des fossiles des couches tithoniques des Alpes Fribourgeoises, *Mem. Soc. Paléontol. Suisse*, VI, Genève, 1880, p. 58, Pl. V, figs. 14—16.

[96] *l.c.*, p. 147, Taf. XXVIII, figs. 29—31.

the dorsal valve the apical region remains smooth. This is not only the case in casts, as is evident from an examination of a fragment of the shelly test, which has been preserved in the apical region of my specimen.

This form approaches very closely *Rh. trilobata var. Moeschi* as defined by Haas. The resemblance in shape, position of the beak, in the feeble trilobate character and in the arrangement of ribs is so great that one feels tempted to unite the Indian and European fossils. The specimen which resembles our type most nearly is that illustrated by Haas in Plate VII, fig. 8. It is remarkably small, whereas the species in general attains large dimensions, agreeing in this respect with the majority of representatives of the *trilobata* group. The large size is even a distinctive feature of the European types of the *trilobata* group. It seems therefore best to be content with expressing the close relationship of the European and Indian forms without attempting a direct identification, until future researches should acquaint us with equally sized shapes in the fauna of the Spiti shales. Another difference which might be advocated in favour of a separation is the smooth apical region of the dorsal valve in my specimen, whereas in *Rh. trilobata var. Moeschi* the ribs of the dorsal valve reach as far as the apex.

Stoliczka identified the present specimen with *Rhynchonella varians* Schloth. The remarkable resemblance with some forms of that group cannot be denied and Stoliczka's determination is easily understood considering the views which at his time prevailed with regard to the stratigraphical position of the Spiti shales. *Rhynchonella spathica* Davidson,[97] a form of the *varians* group from the topmost beds of the Kelloway, is certainly very similar to our example. There is also a close similarity with several forms from still lower horizons, such as *Rh. Orbignyana* Oppel[98] or *Rh. Pallas* Haas,[99] which are among the more important representatives of the *trilobata* group in the Oolithe stage.

Locality, number of specimens examined.—One specimen (Stoliczka's type) from Kibber, coll. Gerard.

The European types of *Rh. trilobata var. Moeschi* have been quoted from the Oxford and Kimmeridge.

Rhynchonella nov. sp. ind.

(Plate CIII, fig. 4 *a—d*.)

Rhynchonella varians (Schloth.) Stoliczka, Geol. sections Himalaya Mts., Mem. Geol. Surv. of India, V, p. 87 (pp.).

The only specimen available for examination has been preserved as a cast, which is considerably broader than long. Ventral valve flattened with a strongly produced sinus, which originates in the middle of the length of this valve. Beak with an obtuse angle, slightly incurved, provided with a large foramen. Borders

[97] Brit. Foss. Brachiopoda, Vol. IV, Suppl., p. 214, Pl. XXVIII, figs. 5—7.

[98] Juraformation, 1857, synonyms in P. de Loriol and H. Schardt, Etude paléontol. et stratigraph. d couches à Mytilus des Alpes Vaudoises, *Mém. Soc. Paléontol. Suisse*, X, 1883, p. 86.

[99] Brachiopoden der Juraform. v. Elsass-Lothringen, *Abhandl. Geol. Spezialkarte v. Elsass-Lothr.*, II, Heft 2. Strassburg, 1882, p. 210, Taf. V, figs. 11, 12.

without any edges, but slightly curved. Dorsal valve globose, strongly inflated, reaching its maximum thickness in the middle of the length. From this place the shell is produced vertically towards the front, but is curved back somewhat before reaching the front line. Shell strongly trilobate from the ventral, feebly trilobate from the dorsal side. The hinge line exposes a small sinuation towards the dorsal side.

Ribs sharp and densely crowded, 25 on each valve, nine among them situated on the dorsal fold and its lateral slopes, eight on the corresponding sinus. They are obliterating on both valves in the middle of the length, thus leaving the apical region entirely smooth.

The present species appears to belong to the group of *Rhynchonella trilobata*, but is distinguished from all species hitherto described by its remarkable width, the unusually strong inflation of the dorsal valve, and the absence of ornamentation in the apical region. From *Rh. aff. Moeschi* it differs moreover by its densely crowded ribs, the incurved beak and the slight curvature of the hinge-line. The latter character, which reminds us of *Rh. lacunosa*, has also been noticed in the true *Rh. trilobata*, but its general shape is quite different from that seen in our specimen.

A closer resemblance with the latter is shown in *Rh. Thurmanni* Etal.,[100] a form from the European Oxford belonging to the group of *Rh. varians*. The illustration published by P. de Loriol agrees with our type from the Spiti shales in its globose shape and in the smooth surface of the apical region. But from all European localities *Rh. Thurmanni* is known to us by very small examples only, agreeing also in this respect with the typical *Rh. varians*. No true affinity with the present species should therefore be assumed. In my opinion, the *Rhynchonella* from Spiti is an independent species, but I am, unfortunately, unable to form any definite judgment on this subject, as the only specimen available for examination is a cast only. Stoliczka united it with *Rh. varians*, but the differences from that species are sufficient to justify a specific separation, although our present knowledge of the Indian form is very deficient.

Locality, number of specimens examined.—One specimen from Gieumal, coll. Gerard.

Group of Rhynchonella Astieriana D'Orb.

Rhynchonella cf. Astieriana D'Orb.

(Plate CI, fig. 5 *a—d*.)

Suess, Brachiopoden der Stramberger Schichten, *Hauer's Beitraege z. Palaeontographie*, I, 1858, p. 52, Taf. VI, figs. 2, 3.

One young specimen only is before me, provided with a dorsal fold, which is developed asymmetrically. In all its characters of importance it agrees with

[100] Kilian, Note stratigraphique sur les environs de Sisteron, *Bull. Soc. Géol. de France*, 3 sèr., Vol. XXIII, p. 134; P. de Loriol, Oxford superieur du Jura Bernois, *Mém. Soc. Paléontol. Suisse*, XXVIII, 1901, p. 112.

the description and illustration of adolescent examples of *Rhynchonella Astieriana*, which have been given by Suess. The highly erected beak towering above a high deltidium, the point of which is pierced by the foramen, and the curvature of the two valves are especially remarkable. It is on the strength of these characters that I refer the present specimen to *Rh. Astieriana* as *cf.*, although the possibility cannot be excluded that we have to deal here with one of those asymmetrical types, which have been described from the Jurrassic rocks of Kutch by Sowerby and Kitchin.

Locality, number of specimens examined.—One specimen from the coll. Gerard, without the exact locality being mentioned.

Rhynchonella sp. ind.

(Plate CIV, fig. 8 *a—d.*)

A very slender form with flanks equally vaulted. Its most important character is the presence of wings, which are curved backward very strongly. Dorsal fold broad, covered with four ribs, which seem to reach as far as the apex. Slopes of the dorsal fold smooth. Wings ornamented with two ribs, which are diverging strongly from the mesial ribs and reach as far as the middle of the shell. No edge bordering the beak.

Locality, number of specimens examined.—Jandu, Sherik river, one specimen, coll. Griesbach.

Among my materials the genus *Rhynchonella* is represented by a larger number of species than have been described above, but their state of preservation does not allow of any exact determination. Some of them, which belong to the coll. Smith, occur in the Belemnite beds or in the middle division of the Spiti shales, the exact locality of the rest has not been mentioned on the labels accompanying the examples.

Fam. Terebratulidæ King.

Gen. Terebratula D'Orb.

In the collections from the Spiti shales this family is represented very poorly, by five specimens only, all of them preserved so indifferently that not even a provisional determination could be attempted. One example belongs to the group of *biplicatæ*.

GENERAL RESULTS.

In the present part of my memoir the genus *Perisphinctes* and the Brachiopoda have been treated separately. As regards the genus *Perisphinctes* I am bound to confess that the results of my own investigations chiefly depend on the excellent and detailed studies of Uhlig. The second portion comprises a discussion of the facies and life-provinces, which are important for the distribution of Brachiopoda in the Spiti shales.

A.—The Fauna of Perisphinctes.

The species of *Perisphinctes* which have been described in the present memoir, belong to the coll. Schlagintweit and Diener. Such specimens as belong to other collections can all be identified with forms described previously by Uhlig.

Six new species are referable to the sub-genus *Aulacosphinctes*, but three of them only can be considered as typical representatives of this sub-genus, namely, *Aulacosphinctes radialecostatus*, *A. nov. sp. aff. Hollandi*, and *A. nov. sp. aff. Lorioli*, to which this systematic position has been attributed by Uhlig himself.[101] The remaining species belong to the group of *Perisphinctes torquatus* Sow. and the correctness of grouping them with *Aulacosphinctes* is questionable. Three species, which are also new, can be placed in the sub-genus *Virgatosphinctes*. Five species are allied very closely to forms described previously. Two among them are allied with types from the Spiti shales :–

Aulacosphinctes aff. Hollandi.
„ *nov. sp. aff. infundibulum.*

Two with Mediterranean forms :—

Aulacosphinctes nov. sp. aff Lorioli.
Virgatosphinctes contiguus Toucas.

One with a species from Kutch :—

Perisphinctes Shangraensis nov. sp.

Stratigraphical position.—The specimens of the coll. Schlagintweit not having been found *in situ*, a determination of their stratigraphical age must be based on palæontological evidence only. This necessitates some reserve in our conclusions. The specimens collected by Diener occur in the Chidamu beds, which have been correlated with the stages of the Kimmeridge and lower Tithonian by Uhlig.

The three following species belong to the coll. Diener from the Chidamu beds :—

Aulacosphinctes radialecostatus nov. sp.
„ *cf. Hollandi* Uhl.
Perisphinctes Dieneri nov. sp.

Aulacosphinctes radialecostatus is allied very closely to *A. tibetanus* Uhl. The stratigraphical age of the latter has been considered as Lower Tithonian by Uhlig.[102] There is some probability that we shall be correct in assuming the same age for our new species. *A. Hollandi* has been enumerated among the forms from the upper Tithonian by Uhlig.[103] Our species, which has been referred to as *cf. A. Hollandi*, occurs in the Chidamu beds. It has not been preserved sufficiently well to enable us to be sure of its relationship to the group of *P. Mörickeanus*. We cannot, therefore, exclude the possibility of its being a member of the series of

[101] *l.c.*, p. 346

[102] Die Fauna der Spitischiefer des Himalaya, ihr geologisches Alter und ihre Weltstellung, *Denkschr. Kais. Akad. Wissensch. Wien, math. nat. Kl*, Bd. LXXXV, 1910, p. 27.

[103] *l.c.*, p. 21.

lower Tithonian *Aulacosphinctes*, as would be well in accordance with its occurrence in the Chidamu beds.

The geological age of *Perisphinctes Dieneri* is a more difficult question. Its nearest ally, *Virgatosphinctes denseplicatus* Waag., has been recorded from the Umia group of Kutch and included in the species from the lower Tithonian by Uhlig.[104] But the relationship of our species with *P. denseplicatus* is not sufficiently intimate to justify a definite conclusion regarding its stratigraphical age. It might also be urged that *P. Dieneri* is the ancestor of *Virgatosphinctes denseplicatus*, because its body-chamber is provided with the sculpture restricted to the inner whorls of the latter species, or that both species have been derived from one common ancestor, provided with a biplicate ribbing. No value can be attributed to a determination of the geological age, which has been based on external similarities which are apt to lead to very different conclusions. No better evidence can be drawn from a comparison with the group of *P. Lucingensis* from the Transversarius stage. *Perisphinctes Dieneri* is undoubtedly younger, but it cannot be decided at present whether it belonged to the forms characteristic of the Kimmeridge or of the lower Tithonian.

The stratigraphical position of a specimen of *Virgatosphinctes* from the coll. Diener will be treated later on.

Among the species belonging to the coll. Schlagintweit there are some whose stratigraphical horizon can be fixed with tolerable certainty. *Aulacosphinctes divergens nov. sp.*, *Aulacosphinctes nov. sp. aff. infundibulum* Uhl., *Aulacosphinctes sp. ind.* are probably Kimmeridge forms, as suggested by their systematic position as members of the *torquatus* group. *Perisphinctes Shangraensis* is identical with *P. Bleicheri* Waag., which has been recorded from the Umia stage, corresponding with the lower Tithonian in age. In Europe the group of *Perisphinctes (Virgatosphinctes) contiguus* is known from the Kimmeridge and Tithonian stages. My specimen of *V. contiguus* from Shangra agrees with the lower Tithonian type from the Ardèche, described by Toucas.

Some difficulty is experienced in defining the stratigraphical age of *Perisphinctes Dacquei nov. sp.* All the nearly allied species, such as *Perisphinctes Beyrichii* Futt., *P. bathyplocus* Waag., *P. indogermanus* Waag., and the group of *P. plicatilis* are characteristic of the Oxford stage, the majority of the Transversarius beds. *Perisphinctes indogermanus* only has been quoted from the Dhosa oolithe or lower Oxford. There is no relationship whatever with geologically younger types. On the other hand the Oxford stage as represented in the Spiti shales is extremely poor in fossils and no species of *Perisphinctes* has as yet been recorded from it. We must therefore be very cautious in attributing *Perisphinctes Dacquei* to the Oxford stage. Provided future researches should prove this correlation, which is made here with the greatest reserve only, to be correct, special stress should be laid on the near affinity of this species to the fauna of Kutch, an affinity which has been noticed in all the Oxford species from the Spiti shales hitherto known.

[104] *l.c.*, p. 27.

Although there is nothing in the characters of *Perisphinctes alternecostatus*, which directly points to a definite stratigraphical zone, we may be allowed to refer it to the Chidamu beds on account of its close affinity with *P. Dieneri*. *Aulacosphinctes nov. sp. aff. Lorioli* has been enumerated among the species from the Tithonian stage by Uhlig. *Virgatosphinctes nov. sp. ind.* is perhaps referable in stratigraphical age to the lower Tithonian, in accordance with its affinity to *P. denseplicatus* Waag. We must, however, bear in mind its equally close relationship with forms of the group of *P. Castroi* from the Oxford stage. The possibility can therefore not be excluded that with richer materials at hand we might arrive at a different conclusion as to its age. The latter form has been collected by C. L. Griesbach, together with some fragments of Belemnites belonging to the group of *Belemnites Gerardi* Opp.

Thus we arrive at the following grouping of the species described above, according to their stratigraphical position :—

LOWER TITHONIAN.

Perisphinctes Shangraensis nov. sp.
Aulacosphinctes radialecostatus nov. sp.
Aulacosphinctes cf. Hollandi (nov. sp. ?).
Virgatosphinctes contiguus Toucas.
Virgatosphinctes (?) nov. sp. ind.

KIMMERIDGE.

Aulacosphinctes divergens nov. sp.
Aulacosphinctes sp. ind.
Aulacosphinctes nov. sp. aff. infundibulum Uhl.

OXFORD.

Perisphinctes Dacquei nov. sp. (?).

The following two species have been found in the Chidamu beds :—

Perisphinctes Dieneri nov. sp.
Perisphinctes alternecostatus nov. sp. (?).

Zoo-geographical affinities.—The zoo-geographical affinities of the fauna of the Spiti shales have been discussed so carefully by Uhlig,[105] that very little can be added on the strength of an examination of materials much more scanty and restricted. Nevertheless I hope that my notes on the differences between *Virgatites* and *Virgatosphinctes* will not be found useless.

Two of the species of *Perisphinctes* described in this memoir are allied nearly to Mediterranean forms, *Aulacosphinctes nov. sp. aff. Lorioli* Zitt. and *Virgatosphinctes contiguus* Toucas.

The first species is a typical representative of *Aulacosphinctes* in its involution and cross-section. These features of sub-generic importance are less promi-

[105] Die Fauna der Spitischiefer des Himalaya, etc., *Denkschr. Kais. Akad. d. Wissensch. Wien, math. nat. Kl.*, LXXXV, 1910

nent in the European *Aulacosphinctes Lorioli*, which is more involute and provided with compressed whorls. Such high and strongly compressed shapes are altogether absent among the *Aulacosphinctes* of the Spiti shales. It is the evolute character of the whorls and the low cross-section, together with the development of an external furrow, which separates this group so sharply from all allied forms. But the European representatives of the sub-genus *Aulacosphinctes* are provided with compressed whorls, if we make an exception in the case of *A. pseudocolubrinus* Kilian and *Perisphinctes eudichotomus* Zittel, which approach the Himalayan types of the sub-genus *Aulacosphinctes* most closely. Its nearest ally among the Indian species, *A. linoptychus* Uhlig,[106] is distinguished by its lower transverse section. A detailed examination of the *Virgatosphinctes* from the Spiti shales also shows the majority of them to differ from the congeneric forms in Europe by a more bulky shape. One might consequently be inclined to consider this difference in the height of the cross-section as a provincial peculiarity of the *Perisphinctes* stock of the Indian region. This suggestion is corroborated by the fact that in the Jurassic rocks of Argentina the sub-genus *Aulacosphinctes* is not only widely distributed, as has been made evident by Steuer and Uhlig, but that in this region, exactly as in the fauna of the Spiti shales, all the forms are distinguished by low transverse sections.

The second species of Mediterranean habit is *Virgatosphinctes contiguus* Toucas. The occurrence of this Alpine group in the Spiti shales is well known and does not need any further comment.

A question of considerable interest, which has been discussed recently, is the occurrence of either *Virgotites* or *Virgatosphinctes* in the Jurassic deposits of the Andine region in Mexico and Argentina.[107]

[106] *l.c.*, p. 357, Pl. XLII, fig. 4.

[107] The memoirs dealing with this problem are contained in the following list:—

Boese u. Burckhardt, Neue Untersuchungen über Jura und Kreide in Mexico, *Centralblatt f. Mineral. etc.*, 1. u. 15. Oktober 1910.

C. Burckhardt, La faune Jurassique de Mazapil, *Bolet. Inst. Geol. de Mexico*, No. 23, 1906.

C. Burckhardt, Beiträge zur Kenntnis des Jura und der Kreideformation der Cordillere, *Palæontographica*, L. 1903.

C. Burckhardt. Bemerkungen über die russisch-borealen Typen im Oberjura Mexicos und Südamerikas, *Centralbl. f. Mineral., etc.*, 1911, p. 477.

C. Burckhardt, Schlusswort zur Diskussion über die russisch-borealen Typen im Oberjura Mexicos u. Südamerikas, *ibid.*, p. 771.

R. Douvillé, Cephalopodes Argentins, *Mém. Soc. Géol. de France, Paléontologie*, Vol. XVII, fasc. 4, Mém. No. 43, 1910.

R. Douvillé, Un Virgatites du Caucase occidental, origine Mediterranéenne de ce genre, Ataxioceras. Pseudovirgatites et Virgatosphinctes, *C. R. somm. Soc. Géol. de France*, 7 Nov. 1910.

O. Haupt. Beitraege zur Fauna des oberen Malm u. der Unteren Kreide in der Argentinischen Cordillere. XII, Teil der Steinmann, schen Beitraege zur Geol. u. Palaeontol. v. Südamerika, *Neues Jahrb. f. Mineral., etc.*, Beilagebd., XXIII. 1908.

Mikhalski, Die Ammoniten der unteren Wolgastufe, *Mém. Com. Géol. St. Pétersbourg*, Vol. VIII, No. 2, 1890-94.

S. Nikitin. Einiges über den Jura in Mexico und in Central Asien, *Neues Jahrb. f. Mineral., etc.*, 1890. II.

V. Uhlig, Über die sogenannten borealen Typen des südandinen Reiches, *Centralblatt f. Mineral., etc.*, 1911, pp. 483, 517, 536.

I wish to say a few words concerning this question, having a very large portion of the materials before me, on which the new sub-genus *Virgatosphinctes* has been based by Uhlig.

One fact which deserves special mention is the occurrence of the sub-genus *Virgatosphinctes* in the Jurassic deposits of Russia. It has been noticed, it is true, but very rarely, and never in the lower Volgian stage. From Gorodizke near the river Volga, a small number of forms have been described by Pavlow,[108] which must be attributed to the sub-genus *Virgatosphinctes*.* *Perisphinctes contiguus* Pavlow shows the distinctive features of *Virgatosphinctes* in its biplicate sculpture, in the ornamentation of its body-chamber, and in the rich ramification of its sutures. I am inclined to assume a similar systematical position of *P. lictor* Pavlow[109] although the absence of inner volutions in Pavlow's type does not permit a safe judgment. To the *contiguus* group another of Pavlow's species—erroneously identified with *Perisph. simoceroides* by that author—might also be referred, as far as we may judge from the character of its ribbing. It must, however, be remarked that the broad saddles in its sutural line are not in accordance with the sutures of *Virgatosphinctes* but approach rather the lobal line in *Virgatites*. I shall explain the importance of this feature for a classification of *Perisphinctes* more thoroughly later on. The last form showing affinities with *Virgatosphinctes* is *Perisphinctes cf. Polyplocus*, but it is rather difficult to refer this species with certainty to any of the groups of that genus. The broad and deep intercostal valleys and the deep position of the branching points of the fasciculi of ribs remind us of *Virgatites*. Certain significant divergences from *Virgatosphinctes* are revealed on closer examination. Nor can it be attributed to *Ataxioceras*. On the whole Pavlow's type-specimen is too fragmentary to establish its relationships at present with any certainty.

All the specimens mentioned occur, associated with a large number of *Perisphinctes*, whose state of preservation precludes any exact determination, in a bed two meters in thickness, which is immediately overlaid by the bed containing true *Virgatites*. Together with the four Ammonites quoted above, *Exogyra virgula*, *Aucella mosquensis*, and *Hoplites* (*Aulacostephanus*) have been found in this bed by Pavlow. This bed, which has not yielded any *Virgatites*, is underlaid by the zone of *Aspidoceras acanthicum*. It has been correlated with the topmost Kimmeridge by Pavlow.

From the Jurassic beds of Orenburg a considerable number of *Perisphinctes* have been described by Semenow.[110] The results of Semenow's examinations have been discussed by Uhlig.[111] Provided Semenow's unsatisfactory determinations

[108] Les Ammonites de la zone à Aspidoceras acanthicum de l'Est de la Russie, *Mém. Com. Géol. St. Pétersbourg*, II, 1886.

*A. Pavlow (Pavlow et Lamplugh, Argiles de Specton, *l.c.*, p. 540) is inclined to consider those species as transitional shapes connecting *Perisphinctes* and *Virgatites*.

[109] *l.c.*, Pl. VII, fig. 2.

[110] Nouvelles données sur la faune Jurassique du Gouvern. d'Orenburg, St. Pétersburg, 1896.

[111] *Neues Jahrb. f. Mineral., etc.*, 1897, II, p. 325.

are correct, they would prove the existence of four species from the Acanthicus zone, namely :—

Perisphinctes cappillaceus
„ *ardescicus*
„ *unicomptus*
„ *lictor*

and two species from higher beds, namely :—

Perisphinctes ulmensis
„ *cf. geron*

to be referable to *Virgatosphinctes*.

From a second locality Semenow described *Virgatites virgatus* and *V. cf. Nikitini*. Uhlig[112] utters grave doubts as to the correctness of those identifications, which he finds not to be in accordance with Sokolow's investigations. In Sokolow's memoir,[113] which, unfortunately, is known to me from short extracts only, a distinct bed (horizon of Vetlanka) has been mentioned, distinguished by the presence of numerous examples of *Virgatites scythicus*, *Perisphinctes cf. acuticostatus* Mikh., *P. Nikitini* Mikh., *P. contiguus* Pavl., *P. nov. sp. aff. Roemeri*. Sokolow considers this horizon as a bed intermediate between the topmost Kimmeridge and the lower Volgian stage, being overlaid immediately by a bed containing *Virgatites virgatus, dorsoplanus, Pavlowi*, and *Quenstedti*.

The horizon of Vetlanka is of special interest, being proof of an association of *Virgatites* and *Virgatosphinctes*. No illustrations have unfortunately been published by Sokolow, but, from what has been said above, the presence of a form belonging to the Mediterranean group of *Virgatosphinctes contiguus* is no longer astonishing. More puzzling is the occurrence of true *Virgatites* (*V. scythicus*) in beds underlying the horizon of *Virgatites virgatus*. The sudden occurrence of *Virgatites* has been explained by the majority of authors by immigration from distant seas. Its discovery in beds lower than the horizon of *Virgatites virgatus*, and its association with Mediterranean types of *Virgatosphinctes*, seems not to favour this hypothesis. A development of *Virgatites in situ* from these Mediterranean types cannot yet be ascertained, *Virgatites* appearing in the horizon of Vetlanka in typical shapes and in large numbers, without any transitional shapes connecting them with the associated species of *Virgatosphinctes*. But the palæontological materials from the passage beds between the Kimmeridge and Volgian stages are as yet so scanty that we must not give up the hope that future discoveries will bring to light such transitional forms.

In the zone of *Virgatites virgatus* entirely different conditions prevail. Although immense material of enormous variability has been collected in this zone, there is not a single form present which approaches more closely the equatorial stock of *Virgatosphinctes*, which is still in the acme of its development in the

[112] Die Fauna der Spitischiefer des Himalaya, etc., *l.c.*, p. 44.

[113] Zur Geologie von Uetzkaia Zastchita, *Isvestija Orenburg'sche Abteil. Russ. Geograph. Ges.*, Vols. XVIII—XIX, 1903-04.

lower Tithonian. Among the species of *Virgatites* described by Mikhalski[114] there are, however, several forms which would certainly not have been referred to *Virgatites*, if found outside central Russia, but which in the Volgian stage cannot be separated from the rest of this sub-genus.

If we consider *Virgatites virgatus* as the prototype of the sub-genus and the stages of development characterised by fasciculi with deep intercostal furrows, backward-turned ribs and a reduction of sculpture following the fasciculi, as typical ones, *Virgatites Zarajskensis* must be grouped with *Virgatites*, although inner volutions can barely be distinguished from *Virgatosphinctes*. Nearly all the forms belonging to this group of *V. Zarajskensis* exhibit the stages of development mentioned above, with the solitary exception of *Virgatites Quenstedti* and *V. Miatschkoviensis*. *V. Quenstedti* exhibits a peculiar sculpture, showing neither the stages of fasciculi nor of reduction in the ornamentation. But this might be considered as a peculiar course of development only, there existing a very close genetic connection with other forms of *Virgatites* in the shape and sculpture of the immature volutions. *Perisphinctes Miatschkoviensis* does not exhibit any of the stages characteristic of typical representatives of *Virgatites*, but approaches rather the group of *Perisphinctes contiguus* in the biplicate ribbing of the inner whorls and the intercalation of triplicate virgatotomous ribs in more advanced stages of growth. In this respect it is closely allied to the form which Pavlow united with *P. simoceroides*. The only feature which this species has in common with *Virgatites* is the simple sutural line, which is but feebly ramified. The isolated occurrence of *Perisphinctes Miatschkoviensis* in the lower Volgian is another reason in favour of referring that species to *Virgatites*.

The typical sculpture of *Virgatites* is absent in *Olcostephanus Lomonossovi*, a very strange form, which cannot be attributed either to *Virgatites* or to the Mediterranean stock of virgatotomous *Perisphinctes*.

In the group of *Perisphinctes dorsoplanus* the distinctive features of *Virgatites* are not developed, as has been pointed out by Mikhalski himself. Backward curved fasciculi of ribs are entirely absent in this group, and, as far as we can guess from the description and illustrations, no reduction of the sculpture has been noticed. On the one hand, it is true, immature examples are found occasionally with biplicate and trichotomous ribs alternating, on the other hand, large fragments of body-chambers occur with exclusively biplicate or undivided ribs, but no specimen is known with those two stages of ornamentation following each other regularly, and besides the types mentioned immature examples with exclusively biplicate ribs and old ones with a complicated sculpture are not rarely met with. *Perisphinctes dorsoplanus* is a rather common species, represented by a large number of examples. It does not exhibit any reduction of its ornamentation after the stage of trichotomous ribs has been reached, but those trichotomous ribs are followed by even more complex rib-bundles, in which the number of ribs increases to four. But the division of ribs does not agree with

[114] Die Ammoniten der unteren Wolgastufe, *Mem. Com. Geol. St. Pétersburg*, Vol. VIII, No. 2, 1890-94.

that seen in *Virgatosphinctes*. There exists no similarity between this group and *Virgatosphinctes*, excepting the inner whorls with a biplicate trichotomous ornamentation.

I have attempted to demonstrate that in the genus *Virgatites* several separate branches have been united, which follow different lines of development and have been amalgamated in one single sub-genus on the strength of the following characters only :—

1. Reduction of the sutural line
2. Occurrence in a distinct geological horizon
3. Restriction to a distinct zoo-geographical province
4. Impossibility of a phylogenetic connection with other groups from distant zoo-geographical regions.

The polyphyletic origin of the Ammonites of the lower Volgian has been clearly defined by Mikhalski, who distinguished several genera among them. The amalgamation of all those forms in one genus, *Virgatites*, is due to Pavlow, but to me the fauna of the lower Volgian appears rather to be composed of several distinct groups of Ammonites, which are specialised very strongly. Special stress must be laid on the association of such forms as are subject to a remarkable variability. Thus we cannot be astonished to find analogies in the sculpture of one or several stages of development in Ammonites from other regions occurring in beds of similar stratigraphical age. External similarities of this character are not sufficient to elucidate the relationship of certain forms from distant regions with boreal elements.

A close examination of the interesting species from the Cordillera of the Argentine leads to the conclusion that a single one only is a typical representative of the sub-genus *Virgatosphinctes* in all its distinctive features. This is *Perisphinctes aff. pseudolictor* Burckhardt, as has been demonstrated by Uhlig. The overwhelming majority of Argentine species agree with *Virgatosphinctes* in all characters of ornamentation, but differ from that sub-genus in the arrangement of sutures. This second group of forms includes, according to my opinion, the following species :—

Perisphinctes contiguus Burckh.
„ *aff. transitorius* Burckh.
„ *cf. Nikitini* Burckh.
„ *Beltranensis* Burckh.
Virgatites australis Burckh.
„ *dorsoplanus* Burckh.
„ *aff. apertus* Burckh.

All these forms are allied to one another so nearly that they cannot be separated, but must be united in one sub-genus. In none of them does the sculpture exhibit the character of true *Virgatites*. They have never fasciculi of ribs deflected backwards, nor any reduction of ornamentation. It is only the inner nucleus which in its more simple ribbing reminds us either of the series of *P. dorsoplanus* or of *P. Zarajskensis*. But similar ribs are also found in immature

individuals of *Virgatosphinctes*. On the other hand the sutures of these Ammonites from the Argentine resemble much more closely the sutural line of *Virgatites*, although they are not exactly identical with it. The most important feature of distinction has been recognized by Uhlig. The height of the siphonal saddle exceeds that of the principal lateral saddle, whereas just the reverse is the case in *Virgatites*. Among the equatorial stock of *Perisphinctes* with virgatotomous ribs no fauna of *Virgatosphinctes* has been described as carefully as that from the Spiti shales. In this fauna one and the same type of sutures prevails throughout the entire group: richly ramified lobes with a strongly retrieved second lateral lobe, and with a large obliquely sloping first auxiliary lobe, which, as a rule, is developed more strongly than the second lateral one and terminating at a lower level. Among all the American species included in the above list *Perisphinctes australis* is the one which approaches most nearly *Virgatosphinctes* in the position of its first auxiliary lobe and of the umbilical lobe in general, although it is considerably less ramified. In all the other species the first auxiliary lobe has been reduced to a simple indentation, the second lateral lobe is larger and not retrieved.

This type of Argentine *Perisphinctes* is not known in Spiti nor from any other place within the region of the Tethys.

From the Mediterranean and middle European regions many species of *Virgatosphinctes* have been described, but the majority of descriptions are not satisfactory, the sutures especially having been examined in very few cases only. As far as they are known, their arrangement agrees with that seen in the Himalayan type from the Spiti shales. Although it cannot be absolutely proved that the American type of suture is absent from the Mediterranean province, yet there is no great probability of its presence. The only species which might suggest a comparison is the form from the lower Volga described by Pavlow, whose sutures are, however, very imperfectly known to us. But as there is very little likelihood of a direct genetic connection between the *Perisphinctes* faunæ of the Argentine and Southern Russia which could only have been effected by the way across the Himalayan zoo-geographical province, I deem it preferable to assume that the reduction of sutures was acquired independently by different phyla of Ammonites in different countries.

Among all the Argentine *Perisphinctes* no species is related to *Virgatites* more closely than *P. scythicus* Burckh. (*mendozanus nov. sp.*). The fasciculi of ribs, although not defined quite distinctly, occasionally show the oldest branch to be deflected backward. The sculpture in the final stage of development cannot be called "reduced." To each main rib an equal number of secondary branches is counted, including the intercalated ribs, whereas in *Virgatosphinctes* an increase of the secondary ribs branching off from the main stem is noticed, the external ribs remaining invariably densely crowded, the main ribs diverging gradually. On the whole, the terminal sculpture of *Virgatosphinctes* is undisturbed and passes gradually into the ornamentation of the inner whorls. This is not the case in the Argentine species, which thus in their total habit deviate somewhat

from the normal types of *Virgatosphinctes*. To this must be added the remarkable similarity of the sutures in *Perisphinctes mendozanus* and *Virgatites* as has been demonstrated by Burckhardt, the second lateral saddle slightly exceeding the siphonal one in height.

We should probably not hesitate in grouping *P. mendozanus* with *Virgatites* had Burckhardt's specimen been collected in Russia associated with other forms of the group of *P. Zarajskensis*. But it is impossible to do so considering its association with so many other forms in the Argentine Jura which cannot be separated, being connected among each other more closely than are the Russian representatives of *Virgatites*.

The majority of Argentine *Perisphinctes* form a well-defined and well-circumscribed series of forms from which *P. mendozanus* can be separated as little as *P. Quenstedti* (*Burckhardti* Douv.), although the latter deviates more than any other from the rest of Andine congeneric species.

The difficulty of grouping the Mexican species of *Perisphinctes* is intensified by their bad state of preservation. Several satisfactory illustrations exist of *P. Mexicanus*. This species does not exhibit the sculpture characteristic of *Virgatites*, neither fasciculi of curved ribs, nor a reduction of ornamentation in full-grown individuals. The sutural line is rather richly ramified, but the most important element, the umbilical lobe, has not been preserved. Burckhardt himself hinted at the close affinity of a second species, *Perisphinctes danubiensis*, whose sutures are unknown, with a Mediterranean form. All these forms, together with *P. Andesensis* Douv. and *P. australis* ought to be referred provisionally to the Andine stock of *Perisphinctes* and their grouping be delayed until richer materials be available for examination.

It is almost impossible to ascertain the true systematic position of the species described from the Cordillera by Haupt, the number of illustrations being too scanty. His *Virgatites argentinus* seems to approach rather closely the group of *Perisphinctes dorsoplanus*, although the sutures are ramified more richly. Its systematic position is, therefore, somewhat doubtful. The remaining forms which have been placed in *Virgatites* by Haupt should be included in the Andine group of the genus *Perisphinctes*. Together with them *Virgatosphinctes aff. pseudolictor* Choff. has been found.

It is evident from the facts enumerated that the stock of Argentine *Perisphinctes* forms a well-defined group of closely allied species, their extreme types approaching *Virgatites*, whereas the typical representatives of the stock are connected genetically with *Virgatosphinctes*. This genetic connection is corroborated by their association with true *Virgatosphinctes*. Now the question of grouping the Andine stock with either *Virgatites* or *Virgatosphinctes* would be of minor importance, were those two sub-genera not distributed in two separate zoo-geographical regions. It cannot be understood clearly from Burckhardt's eminent monographs whether he considers the species included by him in the sub-genus *Virgatites* as boreal elements which emigrated from the Arctic region into the Andine province where they met with the original Mediterranean fauna, or is

inclined to explain their generic agreement with *Virgatites* by their morphological similarity. It is difficult to retain the first hypothesis taking into consideration the close connection of all forms of the Andine stock. A generic connection of Burckhardt's types with *Virgatites* might, however, be advocated but interpreted in the sense of regarding the Andine Ammonites as primitive ancestors of the more highly specialised Russian *Virgatites*. It seems, however, difficult to point out a way by which those forms might have immigrated into the Boreal province. As no direct communication between the Boreal and Himalayan seas has as yet been proved to exist, the only way that remains is across the Alaskan region (northern Andine province). But in the numerous collections from Upper Jurassic horizons in that region (as compiled by Dacqué[115]) the sub-genus *Virgatites* and all forms of *Perisphinctes* resembling *Virgatites* are entirely absent.

Considering the unsafe ground on which the palæo-geography of those regions is as yet based, we might leave the solution of the above problem to the future, if only convincing proofs were available for the supposed generic connection. Such proofs would be furnished if we should find in those regions the whole peculiar association of forms which characterises the lower Volgian stage, without attributing a special importance to slight specific differences, or, at least, some species absolutely identical with boreal forms which could not be united with any but with boreal faunistic elements. This is, however, not the case, as has been made evident in the preceding statement.

Even before Burckhardt, Nikitin[116] asserted his inability to distinguish specifically one of the Mexican Ammonites from a Russian *Virgatites*. But this conclusion was based on the examination of a single specimen only and it will be understood easily that to-day with Burckhardt's excellent memoirs at hand, and with a more intimate knowledge of the Andine faunæ, a different value must be attributed to this similarity. Quite recently Sokolow,[117] as far as I can gather from an unsatisfactory translation of his Russian text, has rejected an identification of the Andine forms with *Virgatites*. Their unquestionable resemblance with *Virgatites* might be considered as a case of convergency as long as no strong reason can be urged in favour of a mixture of faunæ having their habitat in regions so remote from one another as the Boreal and the southern Andine provinces.

As regards the genus *Virgatosphinctes* in its relationship to the Andine *Perisphinctes*, we should not underrate the differences in the sutural lines, which I am inclined to consider as a feature of even sub-generic importance. The arrangement of the sutures remains a constant character in all the representatives of *Virgatosphinctes* in the fauna of the Spiti shales. Nevertheless a close relationship between the forms in the Andes and in the Tethys certainly exists

[115] Die Stratigraphie an den Raendern des Pazifischen Ozeans, *Geologische Rundschau*, Bd. II, Heft 8, 1911.

[116] Einiges über den Jura in Mexico und Zentralasien, *Neues Jahrb. f. Mineral., etc.*, 1890, II, p. 273.

[117] Zur Geologie von Iletzkaia Zastchita, *Isvestija Orenburg'sche Abteil. d. Kais. Russ. Geograph. Ges.*, XVIII—XIX.

The discovery of new fossil faunæ will perhaps lessen the peculiar habit of the Andine types which has been demonstrated by Uhlig. But up to now no connecting links between the two series have been made known, and we must, consequently, separate the group from the Tethys and the group from the Andine Jura as two well-defined sections.

Now let us return after this discussion of the affinities of the Andine *Virgatites*-like forms to an examination of the faunistic affinities of the rest of *Perisphinctes*.

Four of the species described in this memoir belong to the typical Indian branch of forms, namely :—

Aulacosphinctes radialecostatus nov. sp.
„ *cf. Hollandi* Uhl.
„ *aff. infundibulum* Uhl.
„ *divergens nov. sp.*

To them *Perisphinctes Dieneri nov. sp.* and *P. alternecostatus nov. sp.* must be added provisionally.

Perisphinctes Shangraensis nov. sp. is common to the faunæ of the Spiti shales and of the Jurassic rocks of Kutch. Its affinity with *Perisphinctes Bleicheri* Lor. has not been made sufficiently clear to justify the establishment of its occurrence in the Jurassic beds of Middle Europe.

A similar remark applies to *Perisphinctes Dacquei nov. sp.* It undoubtedly belongs to a group which has its habitat in the Himalayas, in Kutch and in the straits of Eastern Africa, and should be placed near the European *P. plicatilis.* From Misol, G. Boehm[118] described a form allied very nearly to *Perisphinctes promiscuus* Buk., which perhaps also belongs to the group of *P. Dacquei.* This group must provisionally be classed with the eminently Himalayan element of our fauna.

The results of my examination fully confirm those obtained by Uhlig. The boreal element is entirely absent, but there is a still closer connection with the faunæ of Kutch and Eastern Africa on one hand, and with those of Middle Europe on the other.

B.—The Brachiopoda.

Among the rich fauna of the Spiti shales the Brachiopoda, as far as the number of species and individuals goes, play a very subordinate part only. This fact explains their being but scantily appreciated. Oppel[119] mentions the presence of Brachiopoda among the fossils of the Schlagintweit collection, but did not venture on a determination of their stratigraphical horizon. One single species only could be safely referred to beds of Jurassic age having been found included

[118] Zur Geologie des Indo-Australischen Archipels, Nachtraege V Zur Kenntnis der Suedkueste von Misol, *Zentralbl. f. Mineral., etc.*, 1910, p. 197.

[119] Uber ostindische Fossilreste von Spiti und Gnari-Khorsum, *Palaeontol. Mitteil. aus d. Museum d. kgl. Bayr. Staates*, I, 1863, p. 299.

in a concretion together with *Perisphinctes frequens*. He purposely delayed a detailed description until richer materials should be available for examination.

I had the opportunity of studying the fossil materials from the Schlagintweit collection in the Palæontological Museum in Munich in 1911. Three brachiopods only have been noticed among them which have been obtained undoubtedly from the Spiti shales, bearing the locality "Tibet" on the accompanying labels. A large number of *Terebratulæ* and *Rhynchonellæ* belonging to the collection Schlagintweit from "Hochasien" show a different matrix. No other brachiopods from this collection have been bought by the Directors of the Museum. Oppel's specimens either did not reach Munich and are lost or are identical with the three examples mentioned above, which, in the latter case, must have been chiselled out from the concretion in which they were found included in association with *Perisphinctes frequens*. The labels containing a more exact statement of the locality which was known to Oppel must have been lost.

A few years later some Brachiopoda from the Spiti shales were identified with Dogger species by Stoliczka, as was in accordance with the common view regarding the correlation of that rock-group.[120] I have re-examined his type-specimens. No attention has been paid since to the class of Brachiopoda in the Spiti shales.

My materials are, unfortunately, very scanty and in a bad state of preservation. The Geological Survey of India owns the larger part of them which belongs to different collections. No stratigraphical horizon is known in the majority of examples, only the few collected by Diener in 1892 allow an exact determination of their stratigraphical zone.

In the Spiti shales Brachiopoda are found crowded together in large numbers associated with *Aucellæ*, or more rarely in single individuals with Ammonites included in concretions. Although the specimens have been preserved with their shelly test, the latter, as a rule, adheres to the matrix so firmly that casts only could be chiselled out. The shell is delicate, sparkling, consisting of thin laminæ, and provided with distinct lines of growth. The small number of examples available did not allow an examination of the internal structure. Nor would such an examination have been successful except in very few specimens where the interior of the shell was filled with the soft clay of the Spiti shales. In the majority of specimens the interior was filled with a coarsely crystalline mass of barytes leaving no hope of finding the brachial apparatus preserved satisfactorily. As it is not possible to recognise the internal characters of the matrix from an examination of the surface of the casts, a large number of specimens would probably have to be sacrificed to obtain a satisfactory result. It is perhaps worth mentioning that a pyritic or quartzose matrix within the interior of the shells is not known to me from any of my specimens. Judging from an analogous character of the matrix in Ammonites* we might be induced to refer the

[120] Geological sections across the Himalaya Mts., etc., *Mem. Geol. Surv. of India*, V, 1865, p. 87.

* Uhlig, Die Fauna der Spitischiefer des Himalaya, etc., *l.c.*, p. 33.

majority of the Brachiopoda examined to the Chidamu beds. But even for such conclusion my materials are too scanty.

The entire collection which I have been able to examine contains about 50 specimens, among them a few *Terebratulæ*, the remainder being *Rhynchonellæ*. The *Terebratulæ* are indeterminable, the *Rhynchonellæ* could be referred with great probability to the three extensive groups of upper Jurassic *Rhynchonellæ: Rh. lacunosa, Rh. trilobata, Rh. Astieriana.*

In Middle Europe the group of *Rhynchonella lacunosa* is restricted almost entirely to the "Spongitenfacies" of the Malm. This facies is well developed in different horizons of the Oxford and Kimmeridge and passes gradually into heteropical deposits both vertically and horizontally. Quenstedt believed this facies to be restricted to the Malm γ and ξ in Suabia, thus quoting *Rhynchonella lacunosa* from those two divisions of the upper Jura only. Recently the development of this facies from α into γ has been demonstrated, but it is not yet known whether *Rh lacunosa* is distributed throughout all those stages or restricted to γ. The possibility of such a distribution is evident from the careful investigations of Moesch in the Jurassic rocks of Argovia. In this district a local development of all strata from the Birmensdorf up to the Baden beds in *Scyphia* facies has been noticed. Nevertheless the distribution of the group of *Rhynchonella lacunosa* is quite peculiar. It is represented by *Rh. arolica* in the deepest layer of this series of rocks in the Birmensdorf beds, by *Rh. lacunosa, arolica, sparsicostata* in the topmost layer, the Baden beds corresponding to Quenstedt's Malm γ but is absent from the intermediate Crenularis and Wangen beds, although this absence cannot be explained by a difference in the facies, a facies rich in Spongiæ being met with frequently in those beds, especially in Eastern Argovia.

As has been demonstrated in my above descriptions, *Rhynchonella arolica* and *lacunosa* are related so closely and connected by transitional shapes, that a most intimate genetic connection is obvious. But this development of *Rh. arolica* into *Rh. lacunosa* cannot have taken place in Argovia, the group of *Rh. lacunosa* disappearing together with the Birmensdorf beds and re-appearing with partly identical shapes but with some new varieties in a higher stage which is separated from the lower by the entire zone of *Peltoceras bimammatum.* A similar interruption is seen in Suabia, where no representatives of the group of *Rh. lacunosa* are known from Malm β.

From this distribution of the group in Argovia and Suabia, that in the Malm of the environs of Regensburg and Passau as described by Ammon[121] somewhat deviates. In this district the group of *Rhynchonella lacunosa,* although restricted to the Spongia facies, is developed in different horizons. Beginning in the zone of *Peltoceras transversarium* in the shape of *Rh. arolica,* it passes into the zone of *Peltoceras bimammatum* with the number of shapes belonging to the true *Rh. lacunosa* increasing gradually. But it has not been found in the zone of *Oppelia tenuilobata* which here is not developed anywhere in the *Scyphia*

[121] Juraablagerungen zwischen Regensburg u. Passau, *Abhandl. zool. mineral. Ver. in Regensburg,* 1875.

facies. It is only above that zone in Malm δ, that we meet with the group for a second and last time. The remnants of Jurassic rocks in this district being very scanty, there is some probability of a former local development of Malm γ in the *Scyphia* facies. Thus there is some ground for the suggestion that we have to look in this district for the probable centre of development of the group of *Rh. lacunosa*.

In more eastern districts the group of *Rh. lacunosa* is associated with the Spongia facies less closely. In northern Bohemia it appears in more neritic deposits according to Bruder. In Silesia and Polonia[122] it is found both in the *Scyphia* marls and in the Cephalopod-bearing limestones of the *transversarius* zone and in the corresponding limestones of the *tenuilobatus* zone near Cracovia. In sediments of the Alpine region it is comparatively rare. It is known from the Oxford of Czetechowitz [123] and from the limestone of Stramberg. Although it has been quoted from many other localities, it is difficult to decide whether or not all those forms do really belong to this group. It has been quoted from Kutais[124] and Shamlung [125] in the Caucasus from the more coralligineous deposits of Oxford age in the Crimea,[126] from the Oxford stage of Usambara[127] and of Morocco, from the Oxford of Chile by Bayle, from the Tithonian of Mexico by A. de Castillo.[128] In the majority of those occurrences the facies of the deposits is not known exactly, although at several localities, at least, the group of *Rhynchonella lacunosa* appears either in a true Spongia limestone (Caucasus) or associated with *Spongiæ* (Usambara). This observation is apt to make us the more cautious, as the Spiti shales have been deposited under entirely different conditions and contain an association of animal life quite distinct from that which has been noticed in the sediments quoted above. Thus the specific independence of the group of forms characterising the Spiti shales to which I have alluded in the foregoing descriptions is corroborated by geological facts.

An examination of the group of *Rhynchonella trilobata* leads to different results. This group is not restricted to a distinct facies being common both to the Spongia limestone and to coralligineous sediments. The true *Rh. trilobata* seems to be restricted to the uppermost stages of the Jurassic system, to δ and ε, but representatives of the group allied very closely to *Rh. trilobata*, such as *Rh. moravica*, *Rh. cracoviensis*, *Rh. Moeschi*, reach down into the Oxford and are

[122] Siemiradzki, Der obere Jura in Polen und seine Fauna, *Zeitschr. Deutsch. Geol. Ges.*, XLV, 1893

[123] J. Neumann, Die Oxford fauna von Czetechowitz, *Beitr. z. Geol. u. Palaeontol. Österr.-Ungarns, etc.*, XX, p. 61.

[124] S. Simonowitch, Les environs de Koutais, Guide des excurs., *VII Congres Geol. Internat. St. Pétersbourg*, 1897

[125] M. Neumayr u. V. Uhlig, Ueber die von H. Abich im Kaukasus gesammelten Jurafossilien, *Denkschr. kais. Akad. d. Wissensch.*, Wien, 1892, p. 8.

[126] C. Vogdt, Le Jurassique a Soudak, Guide des excursions du *VII Congres Geol. Internat. St. Pétersbourg* 1897, p. 5.

[127] O. Jaeckel, Oberjurassische Fossilien von Usambara, *Zeitschr. Deutsch. Geol. Ges.*, 1893, p. 507.

[128] Fauna fossil de la Sierra de Catorce. San Luis Potosi, *Bol. Com. Geol. de Mexico*, No. 1, 1895, p. 1, Taf. I.

widely distributed. In the Alps this group is comparatively rare, although it has been described from the limestone of Stramberg by Zittel. The group has been quoted by different authors from nearly all parts of the world. It is known to us from the Caucasus, from Syria, Southern Russia Spain, Morocco, Eastern Africa, Madagascar. Its occurrence in the Spiti shales is consequently not astonishing, considering its universal distribution.

The group of *Rhynchonella Astieriana* is found very often associated with forms belonging to the group of *Rh. trilobata*, but differs from the latter in its geographical distribution by its frequent occurrence in Alpine strata. Notwithstanding its wide horizontal distribution we are not yet sure of its being represented actually in the fauna of the Spiti shales. The same remark applies to *Rh. Hoheneggeri* which hitherto is known to us with certainty from Alpine deposits of lower Tithonian age only, namely, from Stramberg and from the Bernese Alps.

As was to be expected, the palæontological examination of the Brachiopoda from the Spiti shales offers no possibility of referring each single form to a distinct horizon within the Jurassic system. The difficulties of such an attempt, considerable as they are in the class of Ammonites, are increased in this case not only by the scarcity of fossils, but also by the Brachiopoda being very little adapted to serve as leading fossils for distinct geological horizons. Such forms as in other districts are limited vertically are altogether absent in the Spiti shales (group of *Pygope diphya*). All the groups represented in the Spiti shales have a wide vertical range comprising the entire range of the Spiti shales. Nor is there any peculiarity in the association of the groups which is found to be in accordance with that noticed in Middle European and Alpine deposits. It is useless to go into further details until fossils are available which have been collected according to distinct stratigraphical layers.

At a first glance we might be puzzled by finding the nearest allies of the Spiti shales Brachiopoda among those of Middle Europe and of the Mediterranean region. All the groups represented among my scanty materials are universally distributed. The reason why they have been compared in the preceding descriptions with Mediterranean forms chiefly is easily explained by the present state of our knowledge. It is only in Europe that the fauna of upper Jurassic Brachiopoda has been subjected hitherto to a detailed palæontological examination. It is therefore easily understood that for forms with an entirely indifferent habit, like those from the Spiti shales, relationships are found with less difficulty among the numerous European species than among the small number of species known from other regions of the earth.

The deficiency of our knowledge of upper Jurassic Brachiopoda from extra-European deposits is evident from a short review of the Brachiopod fauna of the vast region which zoo-geographically can be united in the "Himalaya-Malayan province."

No upper Jurassic Brachiopoda at all are known from the Malay Archipelago, whose deposits resemble the Spiti shales so closely both in their facies

and in their fauna of Ammonites and bivalves.* An occurrence of Jurassic Brachiopoda in Ladakh, which has been referred to the Oxford by Godwin Austen, is questionable. Davidson described from this place a species of *Terebratula* and *Rhynchonella*,[129] but their upper Jurassic age cannot be considered as certain. From Kutch a rich Brachiopod fauna was described by Kitchin,[130] but their stratigraphical layers do not comprise all horizons represented by Cephalopod faunæ. They occur chiefly in the Bath and Kelloway stages, a few forms only in the Dhosa Oolithe of the Oxford, among the latter with great probability *Rhynchonella fornix* and *Rh. subplicatella*. There exists some external similarity between *Rhynchonella fornix* and *Rh. aff. Moeschi* from the Spiti shales, but no species resembling *Rh. subplicatella* has been noticed in the latter beds. The absence of any close connection between the two faunæ is hardly astonishing, taking into consideration that only the lowest Spiti shales are homotaxial with the Oxford and are rather poor in fossils.

No Brachiopoda are known to us from Hazara and from the Salt Range. A richer harvest of Brachiopoda has been obtained from Eastern Africa. In the Antalo limestone of Abyssinia, an equivalent to the Bajocien of Europe, *Rhynchonella major* Sow. occurs. From a somewhat higher horizon, the Glandaria limestone, Brachiopoda with Syrian affinities were mentioned by Krumbeck.[131]

Then follows the discovery of a form allied to *Rh. lacunosa* in the Jurassic rocks of Usambara by Jäckel. Of still greater interest are Dacqué's reports from Abulkassim.[132] From this locality *Rhynchonella moravica* Uhl. is quoted, a representative of the *trilobata* group, which we have met with in the fauna of the Spiti shales. Dacqué is inclined to bring it into connection with the occurrence of this species at the southern corner of Mt. Hermon as described by Noetling.[133] The majority of authors agree in general in connecting the finds of Brachiopoda from that region with Syrian and European faunæ. Two other *Rhynchonellæ* which were described by Dacqué. *Rh. somalica* and *Rh. Rothpletzi*, do not exhibit any closer relationship with our Himalayan forms. They are all Oxford types.

Two occurrences of Brachiopoda have been reported from Madagascar, two *Rhynchonellæ* from the lower Oolite by Newton,[134] which this author compared to *Rh. plicatella* Sow. and *Rh. concinna*, two species of *Rhynchonella* from the

* A specimen of *Rhynchonella lacunosa arolica* from the island of Buru has been described and illustrated recently by G. Boehm. Neues Jarhb. f. Min. Beilagebd. XXV, 1908, p. 324. He quotes this specimen, which resembles my form from Spiti very closely, from the Rauraisen.

[129] Note on some carboniferous. Jurassic and cretaceous Brachiopoda collected by Capt. Godwin Austen in the Mustagh hills, Tibet, *Quart. Journ. Geol. Soc.*, XXII, 1866.

[130] Jurassic fauna of Kutch. Vol. III, Pt. 1. Brachiopoda. *Palæont. Ind.*, ser. IX, Calcutta, 1900.

[131] Die Brachiopoden und Mollusken fauna der Glandarienkalke. *Beiträge z. Geol. u. Pal. Oest. Ung., etc.*, Bd. XVI, Wien, 1905.

[132] Beiträge zur Geologie des Somalilandes, II, Oberer Jura, *Beitr. z. Geol. u. Palaeontol. Oesterr.-Ungarns, etc.*, XVII, 1905.

[133] Der Jura am Hermon, Stuttgart, 1887.

[134] On a collection of fossils from Madagascar, *Quart. Journ. Geol. Soc.*, LI. London, 1895.

Kelloway by Douvillé,[135] *Rh. Orbignyana*, an oolithic representative of the *trilobata* group, and *Rh. decorata*. From Australia *Terebratula Davidsoni*, *Rhynchonella rustica*, *Rh. solitaria* have been described by C. Moore[136] and referred to the Dogger. From the same region in the vicinity of Champion Bay, G. C. Crick[137] mentions the occurrence of Dogger Brachiopoda.

With these comparatively few quotations the occurrences of Brachiopoda in the upper Jurassic beds of the Himalaya-Malayan province are practically exhausted.

A few words might, perhaps, be added concerning the Jurassic faunæ of Bokhara, from which a small number of Brachiopoda were described by Borissiak,[138] among them *Rhynchonella Orbignyana*, quoted repeatedly as a characteristic representative of the *trilobata* group, and *Terebratula Algoviana*, both of them probably of Kelloway age.

Thus there is no escape from the fact that our knowledge of upper Jurassic Brachiopod faunæ in the Himalaya-Malayan region and in the adjoining districts is as yet extremely scanty, and, more especially, that those horizons which are chiefly developed in the facies of the Spiti shales, the Kimmeridge and Tithonian stages have yielded nowhere in this region representatives of this class of invertebrates. It would probably not be correct to infer from this a less numerous representation of Brachiopoda within the Himalaya-Malayan region. The reason must be looked for in the wide gaps which our knowledge of the Jurassic beds of those districts exhibits in general, and partially, at least, in the small favour with which the results of an examination of Brachiopoda is regarded by palæontologists, if the materials available are not unusually rich in individuals.

[135] Sur quelques fossiles de Madagascar, *Bull. Soc. Géol. de France*, 1904.

[136] Australian mesozoic geology and palæontology, *Quart. Journ. Geol. Soc.*, London, XXVI, 1870.

[137] On a collection of Jurassic Cephalopoda from Western Australia, *Geol. Magazine*, dec. IV, Vol. I, 1897, p. 385.

[138] Sur la faune des dépôts jurassiques de Baissoun-tau, *Travaux du Musée géol. Pierre le Grand près l'Acad. Impér. d. sciences de St. Petersbourg*, III, 1909.

PLATE CI.

Fig. 1 *a, b.* Aulacosphinctes n. sp aff. Lorioli Zittel. Steiger.
„ 2 *a, b.* Aulacosphinctes n. sp. aff. Lorioli Zitt. Steiger.
„ 3 *a—c.* Aulacosphinctes divergens n. sp. Steiger.
„ 4. Virgatosphinctes contiguus Toucas. Steiger.
„ 5 *a—d.* Rhynchonella cf. Astieriana d'Orb. Steiger.

Geol. Surv. of India.

Pl. CI.

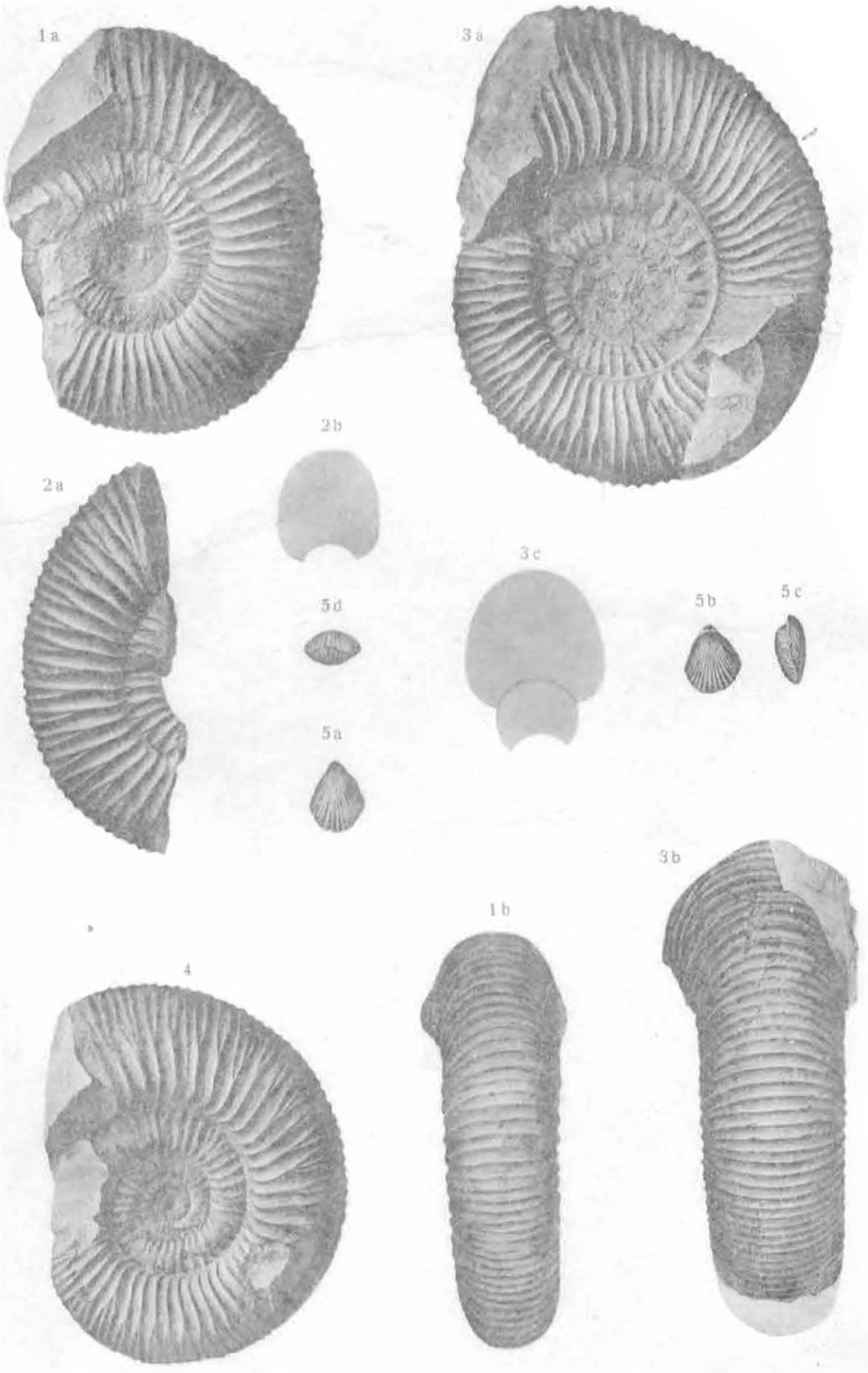

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PLATE CII.

Fig. 1 *a—c.* Perisphinctes Dacquéi n. sp. Steiger.
b. External lobe.
„ 2 *a—c.* Perisphinctes Dacquéi n. sp. Steiger.
„ 3 *a, b.* Aulacosphinctes aff. infundibulum Uhl. Steiger.
„ 4 *a—d.* Rhynchonella aff. Hoheneggeri Suess. Steiger.

3a

1b

1a

2a

4c

3b

4b

4d

4a

2b

1c

2c

PLATE CIII.

Fig. 1 *a*, *b*. **Perisphinctes Dieneri** n. sp. Steiger.

„ 2 *a*—*c*. **Perisphinctes (Aulacosph. ?) Shangraensis** n. sp. Steiger

„ 3 *a*, *b*. **Aulacosphinctes radialecostatus** n. sp. Steiger.

„ 4 *a*—*d*. **Rhynchonella** n. sp. ind.

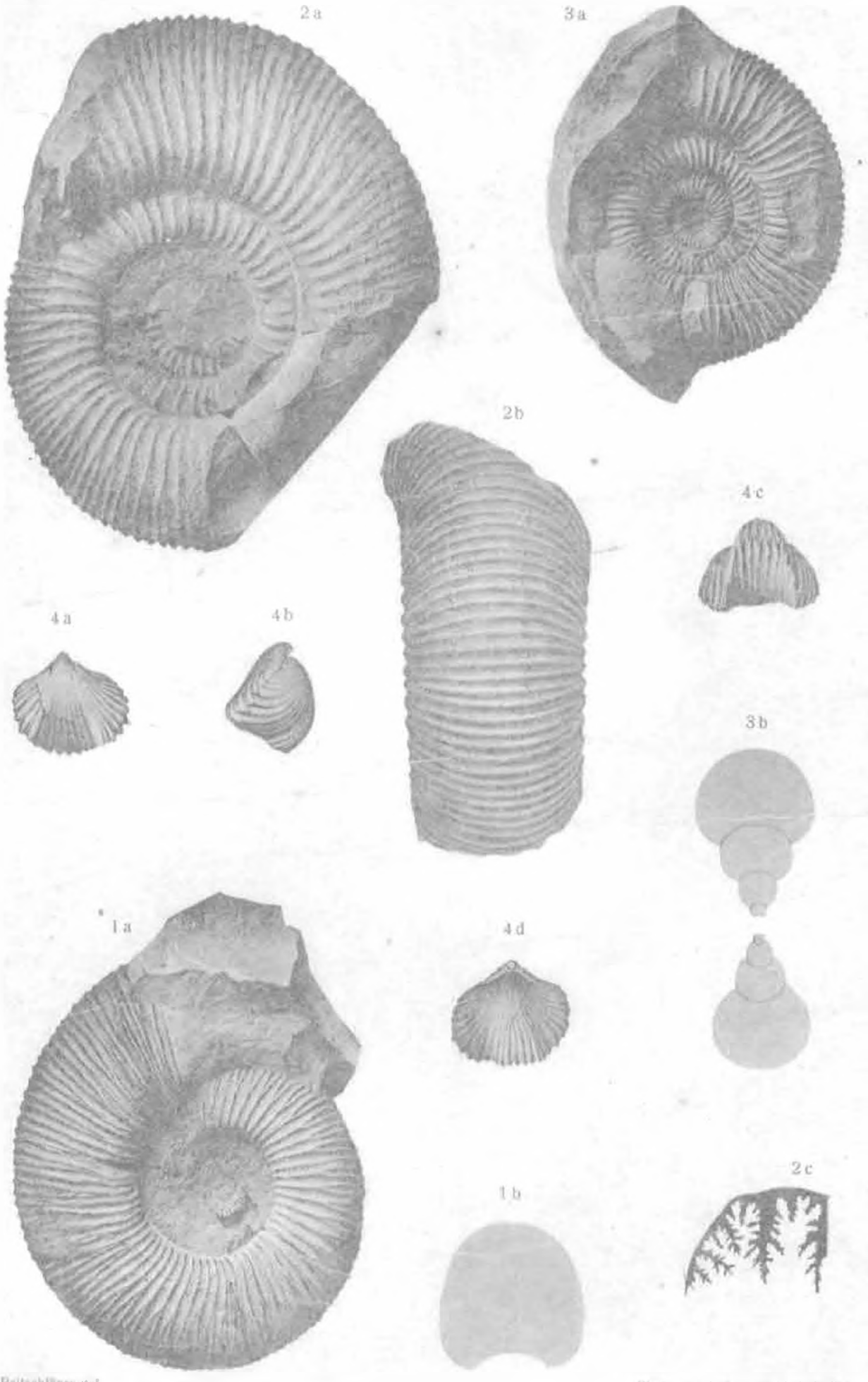

2a
3a
2b
4c
4a
4b
3b
1a
4d
2c
1b

PLATE CIV.

Fig. 1 *a*, *b*. Perisphinctes alternecostatus n. sp. Steiger.

„ 2 *a*, *b*. Virgatosphinctes n. sp. ind. Steiger.

„ 3 *a*—*d*. Rhynchonella aff. lacunosa Quenst. Steiger.

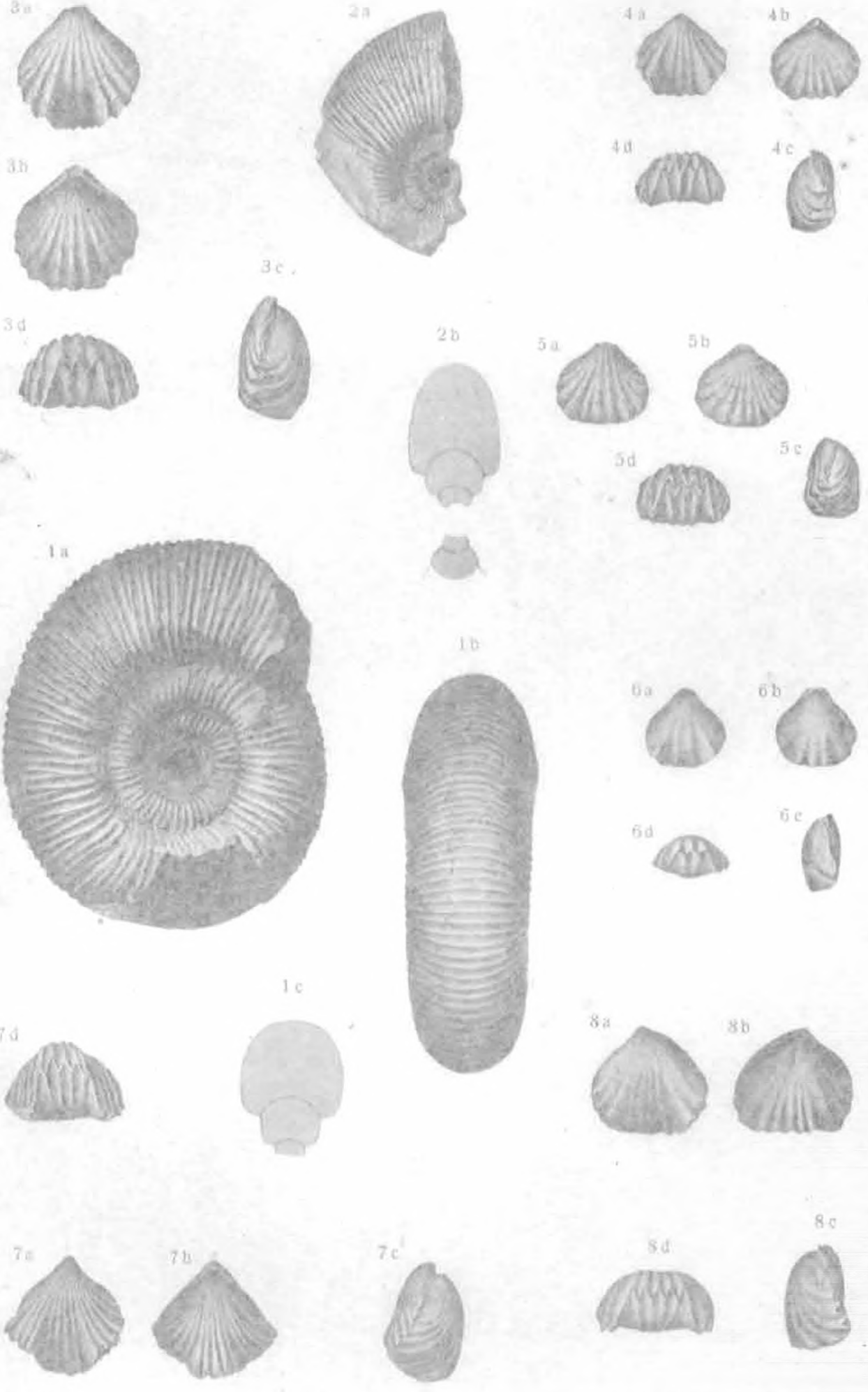
„ 4 *a*—*d*. Rhynchonella aff. lacunosa Quenst. Steiger.

„ 5 *a*—*d*. Rhynchonella aff. lacunosa Quenst. Steiger.
Four ribs in the dorsal fold.

„ 6 *a*—*d*. Rhynchonella aff. sparsicosta Quenst. Steiger.

„ 7 *a*—*d*. Rhynchonella aff. Moeschi Haas. Steiger.

„ 8 *a*—*d*. Rhynchonella sp. ind. Steiger.



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