

HIMÁLAYAN FOSSILS.

VOLUME I, PART 3.

THE PERMOCARBONIFEROUS FAUNA OF CHITICHUN, No. I.

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INTRODUCTION.

In the introduction to the chapter "Cephalopoda of the triassic limestone crags of Chitichun" in Vol. II, Part 2 of the present work, a short notice of the limestone crag of Chitichun No. I (17,710 feet) in Hundés is given. This crag was discovered in 1892 by the expedition to Johár, Painkhánda and the adjoining district of Hundés, in which C. L. Griesbach, C. S. Middlemiss, and myself took part. Even then it was highly probable, that its rich fossil contents were representatives of the middle Productus limestone fauna in the Salt Range, although a more thorough examination had to be waited for, to form the base of an exact determination of their age. Both the large number of forms composing this fauna, which is undoubtedly the richest palæozoic fauna hitherto discovered in the Himálayas, and the peculiar conditions under which it occurs, have led to a special part of this volume being devoted to its description.

A preliminary note on the geological features of this country, one of the most interesting in the Central Himálayas, has been published by C. L. Griesbach in the Records of the Geological Survey of India for the year 1893 (Vol. XXVI, Part I, page 19). In the Denkschriften der kais. Akademie der Wissenschaften in Wien for the year 1895 (Math. Nat. Classe, LXII, p. 588) I have given a more detailed description of the Chitichun region. It is, however, in the present memoir only, that all the geological conclusions will be collected that may be drawn from a minute study of the faunas of the different crags.

Leaving a discussion of the geological facts to the last chapter of this memoir, I shall restrict myself to the following introductory remarks.

The fauna, which I am going to describe, is contained in a white, partly semi-crystalline limestone, alternating with layers of red, arenaceous or earthy limestones, and lenticular intercalations of a red crinoid limestone. This white limestone forms the main mass of the peak Chitichun No. I (17,740 feet) in the Tibetan area

between the Laptal ranges and the head of the Dharma valley. It is from 300 to 450 feet in thickness, and apparently rests on Spiti shales or is associated with intrusive rocks (diabase porphyrite) which penetrate both the limestone crag and the Spiti shales. The Spiti shales are very rich in fossils, especially in ammonites of the genera *Hoplites* and *Olcostephanus*, which, according to information from Dr. Uhlig who examined them, mark this division of the Spiti shales as a representative of the Berrias stage of South-western Europe.

Throughout the limestone crag fossils are common, especially brachiopods, bryozoa and corals. The two trilobites and the only ammonite, which we have been able to secure, came from the upper portion of the block. Although during our expedition in 1892 we could only stay about a week at Lochambelkichak encamping ground, the starting point for an ascent of Chitichun No. I, we visited the crag four times altogether and succeeded in obtaining finally a very large suite of fossils, to Mr. Middlemiss belonging the honour of having found the first trilobite (*Phillipsia Middlemissi*).

The fossils are, as a rule, well preserved, at least such as are contained in the white limestone, whereas those which have been collected in the red arenaceous layers, are frequently crushed and considerably deformed. A disadvantage in the condition of the majority of fossils is their fragility, owing to the numerous planes of cleavage, which intersect them in almost every direction. Nor is the internal structure of the brachiopods, the chief constituents of this fauna, accessible to observation, with the exception of a very small number of specimens, the rest being casts, either hollow or filled by crystals of calcite.

Before entering into the specific descriptions, I feel obliged to express my most sincere gratitude to Professor Waagen, to whom I am greatly indebted for his most valuable assistance and advice.

DESCRIPTION OF FOSSILS.

Class: CRUSTACEA.

Section: ENTOMOSTRACA.

Order: TRILOBITÆ.

Family: PROETIDÆ, Barrande.

Genus: PHILLIPSIA, Portlock.

1. PHILLIPSIA MIDDLEMISSI, nov. sp. Pl. I, fig. 3.

Head and thorax unknown. The single pygidium, by which this species is represented in our collections from Chitichun No. I, was found by Mr. C. S. Middlemiss, in whose honour its specific denomination is proposed.

The pygidium is considerably broader than long, and strongly vaulted. At its anterior border the axial lobe occupies a little more than one third of the entire breadth of the pygidium. Its posterior portion has been partly broken off, but from the outlines preserved we may judge, that its extremity was regularly rounded. Its profile is of a semicircular shape.

The axial furrows are distinctly marked in the vicinity of the proximal border only. Near the posterior extremity of the axial lobe they gradually disappear. The number of axial segments can only be made out approximately. About ten coalesced rings, separated by deep furrows, seem to be present. The lateral lobes consist of seven or eight pleuræ, which terminate within the margin. The lateral lobes are regularly arched, the pleuræ are simple and united at the margin by a smooth rim, which occupies a little more than a third of the breadth of the lobe.

Neither axis nor pleuræ have any ornamentation upon them.

The measurements of this pygidium are as follow:—

Length of the entire pygidium	. . . . .	12.5 mm.
Breadth " "	"	16.5 "
Length of the axial lobe	. . . . .	10.5 "
Breadth " "	" at its anterior margin	6 "
Breadth of the smooth border	. . . . .	2 "

Number of specimens examined.—1.

Remarks.—Among British carboniferous trilobites of the genus *Phillipsia*, *Ph. Cliffardi* Woodw.¹ or *Ph. articulosa* Woodw.² might be compared to the present species as regards the general outlines and the absence of any ornamentation. But

¹ H. Woodward, Monograph of the British Carboniferous trilobites: Pal. Soc., 1883-84, p. 69, Pl. X, fig 8-12.

² H. Woodward, loc. cit., p. 70, Pl. X, figs. 6, 13.

Ph. Cliffordi is of a broader shape, its axial lobe is bluntly rounded at the posterior extremity, and the lateral pleuræ bifurcate as they approach the margins. In *Ph. articulosa* the shape of the pygidium and the characters of the axial lobe and pleuræ are very similar, but it differs in possessing a greater number of coalesced segments (17) and lateral pleuræ (13), a feature, which seems sufficient to justify the specific separation of the Tibetan specimen.

From the caudal shields of *Griffithides globiceps*, Phill., and *Gr. obsoletus*, as figured by Prof. Woodward, this pygidium differs principally by its simple lateral pleuræ, these being double in the two species mentioned above. *Griffithides globiceps* is, moreover, distinguished by the corrugated character of its axial lobe.

Among the Russian representatives of the genus *Phillipsia*, which have been described and figured by V. von Möller *Ph. Eichwaldi* Fisch. (Ueber die Trilobiten der Steinkohlenformation des Ural, Bull. Soc. imp. des naturalistes de Moscou, 1867, No. I. Pl. II, fig. 3) somewhat recalls our Tibetan specimen in its outlines and in the development of a broad, smooth marginal rim. It differs, however, by the granulated character of its surface, and by the presence of flat transverse furrows on each of the lateral pleuræ.

Among the trilobites of the permian Fusulina limestone from Sosio in Sicily as figured and described by Gemmellaro (Mem. Soc. Ital. Sci., Napoli, VIII, ser. 3a, No. I) there is no species, which might be advantageously compared with *Ph. Middlemissi*.

Family INDETERMINABLE.

Genus: CHEIROPYGE, nov. gen.

Until 1884 no trilobite, in which the pleural ridges of the pygidium extend beyond the border, was known from carboniferous or permian rocks. The only slight exception from the types possessing a pygidium with definite, even outlines, was *Phillipsia lodiensis* from the carboniferous deposits of Ohio, as described by Meek (Rep. Geol. Surv. Ohio, Vol. II, Pt. II, Palæontology, p. 324, Pl. 18, fig. 3). According to Meek, this species is distinguished by the "fimbriated character of the posterior and lateral margins of the pygidium." Prof. Meek says of this feature: "the segments are continued down and across the sloping border, at the edge of which they terminate in little, pointed projections, so as to present a fimbriated appearance around the posterior and lateral margins." This character is, however, so slight, that it has not been represented in the figure of Meek's type specimen. Nor has Claypole been able to observe the crenate character of the margin of the pygidium in other specimens of *Ph. lodiensis*.

In 1884, however, Prof. E. W. Claypole described and figured¹ the pygidium of a trilobite from the Cuyahoga shales, the uppermost member of the lower

¹ E. W. Claypole.—On the occurrence of the genus *Dalmanites* in the Lower Carboniferous rocks of Ohio: Geol. Mag. Decade iii, I, 1884, p. 303 (woodcut fig. A).

carboniferous system, of Akron in Ohio. This pygidium is characterised by the absence of any marginal tract, and by its segments being "produced for the most part about half their length beyond the marginal line formed by their union, and ending in points, the third, seventh and ninth produced to double the distance and having the appearance of spines." This species has been assigned provisionally to the genus *Dalmanites* Barr. (*Dalmania* Emmr.) by its author under the denomination of *Dalmanites* (?) *Cuyahogæ*.

This reference to the genus *Dalmania* is rather astonishing. In all the typical species of *Dalmania*, which have been described by Barrande, the pygidium is surrounded by a broad, smooth border, across which the pleuræ never extend. In my opinion, this pygidium from Akron more probably belongs to the subgenus *Phæton*, Barrande, a section of the genus *Proetus*.

A second pygidium of a trilobite, provided with pleuræ extending beyond the border, has been collected by myself in the permocarboniferous limestone of Chitichun No. I. I dare not class the species, which I propose as the designation of this pygidium, in the same genus with *Dalmanites* (?) *Cuyahogæ*, Claypole. While the American form may after all be only a representative of *Phæton*, my Tibetan species must certainly belong to a new genus, although we must await the discovery of other parts of the carapace for a complete diagnosis of the latter.

The reasons, which prevent me from classing this form with any of the hitherto known genera of trilobites, will be discussed after a detailed description of its specific features has been given.

1. CHEIROPYGE HIMALAYENSIS, nov. sp. Pl. I., fig. 2 a, b, c.

Head and thorax unknown. Pygidium nearly as long as broad, distinctly trilobate, and moderately vaulted. The axis is distinctly marked off from the lateral lobes, and is composed of 15 coalesced segments. It is strongly conical, with a nearly semicircular profile, elevated considerably above the lateral lobes and equalling a little more than one third of the entire breadth of the pygidium at its anterior end.

The axial segments are rounded on their tops, and separated by deep furrows, which are as broad as their elevated portions. The latter are regularly covered with granulations, whilst the furrows between them remain perfectly smooth. The lateral lobes are more flatly curved than the axis, but are bent down rather abruptly towards their margins. No marginal space or limbus is formed. Each of the lateral lobes consists of six well defined pleuræ, which are interrupted by deep, narrowly rounded depressions. These pleuræ originate as sharp ridges in the furrows, limiting the axial lobe, broaden considerably, as they approach the margin, where they bend suddenly downwards. The posterior pleuræ are broader than the anterior ones. They are not distinctly carinate, although their profile in general takes the shape of a slightly pointed arch. The posterior termination of the axial lobe is surrounded by an axial lappet, which is exactly like the lateral pleuræ, but slightly exceeds them in width. Both the lateral pleuræ and the posterior axial

lappet are ornamented with numerous rounded granulations of equal size. The interpleural depressions are smooth.

The strong projection of each pleura imparts to the margin a crenated appearance, recalling the pygidium in *Cromus*, Barr., of the family of *Encrinuridæ*.

The measurements of the present pygidium are, as follow :—

Length of the entire pygidium	. . . . .	11 mm.
Breadth " " "	. . . . .	12.5 "
Length of the axial lobe	. . . . .	8 "
Breadth " " " at its anterior margin	. . . . .	4.5 "

Number of specimens examined.—1.

Remarks.—Among the pygidia of hitherto described trilobites those of the subgenus *Phaëton* (*Phaëtonides*), Barr., may be first compared.

This subgeneric section has been introduced by Barrande for such species of the genus *Proetus*, which are distinguished by a crenated margin of their pygidia.¹ Of the three species attributed by Barrande to this subgenus, *P. Archiaci* and *P. striatus* are of upper silurian age, whereas *P. planicauda* occurs in deposits of lowest devonian age. This last species has been considered by Novák² as the prototype of a proper subgenus, *Phaëtonellus*. No axial lappet or pleura is developed on the prolongation of the axial lobe, either in the Bohemian species of *Phaëton* or *Phaëtonellus*, or in American *Proetus Verneuili*, which, judging from the figure given by Prof. Hall in his Illustrations of Devonian Fossils (Pl. XV, fig. 18) may also belong to *Phaëton*. On the contrary an emargination of the border always corresponds to the posterior termination of the axial lobe. This is the first important difference between *Phaëton* and *Cheiropyge*. A second difference is in the character of the lateral pleuræ. In *Phaëton* they are flat and divided by a median furrow, reaching from the axial lobe to the pointed extremity of each segment. So remarkable are these two points of difference, that they not only make a reference of the present species to *Phaëton* impossible, but even induce me to believe, that *Cheiropyge himalayensis* belongs to an altogether different family from the *Proetidæ*.

A certain resemblance seems to exist between this Tibetan trilobite and a few silurian forms, which have been included by Barrande in his genus *Cromus*. *Cromus transiens* Barrande (Système Silurien, p. 828, Pl. 43, figs. 18, 19) is a form which at a first glance recalls *Cheiropyge*. This similarity is, however, more apparent than real. There is no axial lappet or pleura, but the posterior element of the axial lobe is produced towards the margin and bordered on both sides by lateral segments. In the external character of the pleuræ there are likewise differences, which make a distinction easy. The resemblance of the present specimen to pygidia of *Cheirurus* is still more distant. I do not know of any other genera of trilobites, which might advantageously be compared with *Cheiropyge*. Nor am I

¹ *J. Barrande*, Notes préliminaires sur le Système Silurien et les trilobites de Bohême, Leipzig, 1846, p. 62; Système Silurien du centre de la Bohême, Vol. I, 1852, p. 433.

² *O. Novák*, Vergleichende Studien an einigen Trilobiten aus dem Hercyn von Bioken, Wildungen, Greifenstein und Böhmen: Palæontologische Abhandlungen, neue Folge, I., 1892, Heft 3, p. 16.

able to give any clue as to its systematic position among this order. The character of its pygidium is however so peculiar, that I believe to be justified in establishing a new genus, although without the knowledge of the cephalothorax a satisfactory diagnosis of the latter cannot be given.

MOLLUSCA.

Class : CEPHALOPODA.

Order : AMMONOIDEA.

Suborder : AMMONEA LEIOSTRACA.

Family : *CYCLOLOBIDÆ*, Zittel.

Genus : POPANOCERAS, Hyatt.

Subgenus : STACHEOCERAS, Gemmellaro (WAAGENINA, Krotow).

The genus *Popanoceras* has been introduced by Hyatt in his Genera of Fossil Cephalopods (Proc. Boston Soc. Nat. Hist., XXII, April 1883, p. 337). In this genus he included three Russian species, which E. de Verneuil had formerly classed among *Goniatites*, viz., *G. sobolewskyanus*, *G. kingianus* and *G. koninckianus*, and, as "extreme form" *Arcestes antiquus*, Waagen, from the cephalopoda beds of the upper Productus limestone.

E. von Mojsisovics¹ in his memoir on the triassic faunas of the Arctic region accepted Hyatt's genus and gave a more appropriate diagnosis, referring to it five Spitzbergen forms and a species from the permian or triassic rocks of Timor, which had been described by Beyrich (Monatsber. k. Akad. Wiss. Berlin, 1867, p. 66) as *Ammonites megaphyllus* and considered as a type of his group of *Megaphylli*.

In the meantime Krotow² united three species of *Popanoceras*, from the Artinskian stage of the Ural Mountains, in a new genus, *Waagenia*, a name which he changed afterwards in *Waagenina*³ as the priority of the former denomination had been claimed by Neumayr for a group (*hybonoti*) of *Aspidoceras*.

In 1887 Gemmellaro⁴ described and figured a large number of species of *Popanoceras* from the permian Fusulina limestone of Sosio in Sicily. His examination of a very rich material led him to a generic distinction of two groups of forms. *Popanoceras sobolewskyanum* furnishes the type of the first group, for which the

¹ E. v. Mojsisovics, Arktische Triasfaunen : Mém. Acad. Imp. Sci., St. Pétersbourg, sér. vii, XXXIII, No. 6, 1886, p. 65.

² P. Krotow, Artinskian stage, Kazan, 1885, (in Russian) p. 204.

³ Mém. Com. Géol. Russ., St. Pétersbourg, VI, 1888, p. 474.

⁴ G. Gemmellaro, La fauna dei calcari con fusulina della valle del Fiume Sosio, nella provincia di Palermo, 1887, Fasc. 1, p. 26

name of *Popanoceras* is retained, while the second group, consisting of such species, as are more nearly allied to *P. antiquum*, Waagen, is elevated to the rank of a separate genus, *Stacheoceras*. To the latter genus likewise belong the forms formerly united in *Waagenia* (*Waagenina*) by Krotow.

The new genus *Stacheoceras* has, however, not been accepted without opposition. It was rejected by E. von Mojsisovics,¹ who considered the characters of difference between *Stacheoceras* and *Popanoceras*, as enumerated by Gemmellaro, to be of a very subordinate importance and not sufficient for a generic or even subgeneric distinction. Karpinsky² came to a similar conclusion in his beautiful memoir on the ammonites of the Artinskian stage, and maintained his view against the arguments of Gemmellaro, who actively defended the introduction of a separate genus for the group of *Popanoceras antiquum* in a special appendix³ to his above quoted monograph. A different view of this question was however taken by K. A. von Zittel, who in his recently published "Elements of Palæontology"⁴ accepted *Stacheoceras* as a proper genus, although he cannot be considered an advocate of too narrowly circumscribed genera.

In face of the results of the somewhat contradictory observations of E. von Mojsisovics, Gemmellaro and Karpinsky, it can scarcely be denied, that among the points of difference between *Popanoceras* and *Stacheoceras*, as enumerated by Gemmellaro, some are either problematical or of only very small importance. This remark applies both to the length of the body chamber and to the character of the sutures. Nevertheless a distinction can be based on the following characters.

Stacheoceras is of a more globose shape, turning discoidal only in later stages of growth. It is provided with a more delicate sculpture, its ornamentation consisting of thin radial striæ only, but often distinguished by the presence of varices. The importance of these characters has been compared by E. von Mojsisovics to that of the differences between two groups of the genus *Arcestes*, viz., the sections of *intuslabiati* and of *subumbilicati*. Since the latter groups have meanwhile been elevated to the rank of subgenera by E. von Mojsisovics⁵ himself, I do not think that this learned author will object any more to a similar treatment of *Popanoceras* and *Stacheoceras*.

A subgeneric distinction between *Popanoceras* and *Stacheoceras* will certainly meet the approval of palæontologists, who agree with Haug as to the advisability of introducing a special subgeneric designation for the Spitzbergen and Siberian species of *Popanoceras*. For these species, which are distinguished by a more complicated sutural line, the name *Parapopanoceras* has been proposed.⁶

¹ E. v. Mojsisovics, Über einige arktische Trias—ammoniten des nördlichen Sibirien: Mém. Acad. Imp. Sci., St. Pétersbourg, sér. vii, XXXVI, No. 5, 1888, p. 18.

² A. Karpinsky, Ueber die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte carbonische formen Mém. Acad. Imp. Sci., St. Pétersbourg, ser. vii, XXXVII, No. 2, 1887, p. 67, 84.

³ G. Gemmellaro, loc. cit., Appendice. Palermo, 1888, p. 10.

⁴ K. A. von Zittel, Grundzüge der Palæontologie (Palæozoologie). 1895, p. 108.

⁵ E. v. Mojsisovics, Die Cephalopoden der Hallstätter Kalke: Abhandlgn. K. K. Geol. Reichsanstalt VI, ii Theil, p. 785.

⁶ E. Haug, Les Ammonites du Permien et du Trias: Bull. Soc. géol. France, ser. iii, XXII, 1894, p. 395.

Another subgeneric denomination will be found necessary for a species from the triassic rocks of British Columbia, which has been described by Whiteaves as *Popanoceras McConnelli*.¹ It is readily distinguished from the Spitzbergen species of *Parapopanoceras* by its very distinctly angulated periphery. The lobes are minutely incised at their base and margins, but the saddles are not distinctly megaphyllic, as is the case in the true *Popanoceratidæ*.

Up to now neither *Popanoceras* nor *Stacheoceras* has been found in deposits of an older than permocarboniferous age. In permocarboniferous and permian strata of a pelagic facies they are the most common ammonites.

The occurrence of a species of *Stacheoceras* in the limestone of Chitichun No. I is therefore of no small geological importance, as, in correspondence with other evidence, it clearly proves these limestones to be younger than upper carboniferous in age.

I. POPANO CERAS (STACHEOCERAS) TRIMURTI, nov. sp. Pl. I, fig. I a—f.

Of this beautiful species the chambered portion of the inner whorls of a specimen attaining a diameter of 55 mm. and a few chambered fragments of the outer volutions are available for examination. It belongs to a group of forms, which are most nearly allied to *Stacheoceras mediterraneum*, Gemmellaro (La fauna dei calcari con Fusulina, p. 29, Pl. IV, fig. 2-6, VII, fig. 11-13) from the permian rocks of Sicily.

In its general shape and outlines my type specimen is very similar to *Stacheoceras Tietzei*, Gemm. (Pl. V, fig. 1-8). It is thickly lenticular, with a very narrow umbilicus and a broadly rounded siphonal part. The involution of the slowly increasing whorls is very considerable. The projection of the spiral of the penultimate whorl meets the last volution above the middle of the height of the latter.

The transverse section is broadly oval. The lateral parts are but slightly vaulted, and slope with regularly increasing convexity towards the umbilicus. No umbilical edge is developed. In the direction of the siphonal area the lateral parts show a very equal curve, and unite with the regularly arched external part without any proper demarcation.

The greatest transverse diameter of the volutions is situated a short distance below the middle of their height.

My specimen is an internal cast without any trace of a sculpture. I am not able to decide whether the shelly substance was smooth or covered with a delicate ornamentation, the fragments of the shelly layer, which have been preserved, being too incomplete and, moreover, deteriorated by weathering. But if any sculpture was ever present, it must have been but very faint.

No varices have been noticed.

¹ *Whiteaves*. The fossils of the triassic rocks of British Columbia : Contributions to Canadian Palæontology, Vol. 1, Part ii, Montreal, 1889, p. 138, Pl. XVIII, fig. 2, 3.

The following measurements have been taken from the specimen, corresponding to a diameter of 52 mm.:—

Diameter of the shell	52	mm.
„ „ „ umbilicus	2.5	„
Height of the last volution { from the umbilical suture	28.5	„
„ „ „ „ preceding whorl	11	„
Thickness of the last volution	29	„

Body chamber.—Unknown.

Sutures.—The projection of the spiral of the penultimate whorl touches, in the last volution, the third lateral lobe at its inner margin. *Stacheoceras Trimurti* must therefore be classed among the species with three lateral lobes, whereas, as a rule, in this subgenus the normal number of lateral lobes (two) prevails.

The sutural line exhibits the semicircular arrangement, which, according to Gemmellaro, is peculiar to the group of *Stacheoceras mediterraneum*. It is only in the vicinity of the anterior margin of the last volution, that I have succeeded in tracing it out entirely. Corresponding to a height of the volution of 27 mm., the sutural line is composed of the following elements.

A very deep and broad siphonal lobe is divided by a median prominence, which reaches only half the height of the siphonal saddle. This median prominence is slightly enlarged at its top, and interrupted by a broad funnel for the entrance of the siphuncle. The two branches of the siphonal lobe, which are very strongly individualised, are longer than any of the following lobes. Each of these two branches is provided with a secondary indentation. The principal lateral lobe is bipartite. All the following lobes are tripartite. The two branches of the principal lateral lobe are quite symmetrically arranged, of equal length, and terminate in sharp points. In the following lobes the central indentation is the largest, but the two lateral indentations on each side are as a rule, not symmetrical.

There are seven auxiliary lobes present.

The saddles are club shaped, and evenly rounded above. They regularly diminish in size from the siphonal saddle in the direction towards the umbilical suture. This is a type of sutures, to which the term “serial” as proposed by Blake,¹ might be advantageously applied.

In later stages of growth a further complication of the sutural line is indicated by the development of an accessory indentation in each of the two branches of the principal lateral lobe. The trifid termination of the following lobes remains however unchanged. This character of the sutural line is clearly developed in the fragment of an outer whorl, the height of which can scarcely have been less than 45 mm. As this fragment is entirely chambered, the species seems to have attained a rather remarkable size.

Number of specimens examined.—1.

Remarks.—Among the Sicilian species of the subgenus *Stacheoceras* the present one is most nearly allied to *St. Tietzei*, Gemmellaro, from which it chiefly differs by

¹ *F. Blake*, on the bases of the classification of Ammonites : Proc. Geol. Ass., XIII, pt. ii, 1893, p. 2.

the absence of varices, and by the shape of the lobes, which in Gemmellaro's species exhibit a bipartite termination. Regarding the character of the sutural line, my Tibetan specimen approaches more nearly *St. mediterraneum*, Gem. In both species the siphonal lobe stands deepest and is of an exactly similar shape, the principal lateral lobe is bipartite, while the remaining lobes show a trifid termination. The only difference consists in the presence of a small accessorial dentation in the outer branch of the principal lateral lobe in *St. mediterraneum*. In their external characters however the two species differ more strongly, the Sicilian form being provided with a comparatively large and funnel shaped umbilicus.

Regarding the development of the sutural line there is no species more nearly allied to the present one, than *Stacheoceras Krassnopol'skyi*, Karp.¹, (= *Waagenina subinterrupta*, Krotow²) from the Artinskian sandstones of Russia. In *St. Krassnopol'skyi* the principal lateral lobe is bipartite and the second lateral lobe tripartite, corresponding to a height of the volution of 4 mm. Corresponding to a height of the volution from 7 to 10 mm., accessory dentations are developed in the branches of the principal lateral lobe. The number of lateral and auxiliary lobes together is six. From a comparison of the development of the sutural line in both species it clearly results, that the siphonal and principal lateral lobes show a bipartite arrangement, each of them gradually developing accessory dentations, whereas in all the following lobes the tendency of a tripartite differentiation prevails.

A similar character of the sutural line has been noticed in *Stacheoceras Parkeri*, Heilprin (Proc. Acad. Nat. Sci. Philadelphia, I, 1884, p. 53, fig. 1-2) from the permocarboniferous rocks of Texas, and in *Stacheoceras sp. ind. aff. Parkeri*, Karpinsky (Mém. Acad. Imp. Sci., St. Petersburg, p. 75, Pl. V, fig. 5) from the Artinskian deposits of [Russia. It is a pity, that only incomplete fragments of all these species have hitherto been discovered, as the largest specimen of *St. Krassnopol'skyi* reaches a diameter of scarcely more than 20 mm. A comparison of outlines with *Stacheoceras Trimurti* is therefore of very little use, as the globose shape of the Russian forms may be peculiar to young individuals only.

In the Indian zoogeographical region the subgenus *Stacheoceras* is represented by three species, the present one from the permocarboniferous rocks of Chitichun No. I, *St. antiquum*, Waagen, from the Jabi beds of the upper Productus limestone of the Salt Range, and *St. tridens*, Rothpletz³ from the permian rocks of Timor. From the two later species *St. Trimurti* is easily distinguished. *St. antiquum*, Waagen (Salt Range fossils, I, p. 28, Pl. I, fig. 10) is more strongly compressed, and its lateral and auxiliary lobes are all provided with a tripartite termination. In *St. tridens* not only are the auxiliary and lateral lobes tripartite but even the siphonal lobe exhibits a trifid termination in each of its two branches.

¹ A. Karpinsky, Ueber die Ammoneen der Artinsk-Stufe: Mém. Acad. Imp. Sci., St. Pétersbourg, ser. vii, XXXVII, No. 2, 1887, p. 73, Pl. V, fig. 10.

² A. Karpinsky, Zur Ammoneen-Fauna der Artinsk-Stufe: Mélangés géol. et pal. tirés du Bull. Acad. Imp. Sci., St. Pétersbourg, I, 20 Nov. 1890, p. 76.

³ A. Rothpletz, Die Perm-Trias-und Jura-formation auf Timor und Rotti: Palæontographica, XXXIX, 1892, Pl. IX, fig. 4, p. 87.

Class : LAMELLIBRANCHIATA.

Order : ANISOMYARIA, Neumayr.

Family : *PECTINIDÆ*, Lam.

Genus : AVICULOPECTEN, M'Coy.

1. AVICULOPECTEN AFF. JABIENSI, Waagen. Pl. I, fig. 4.

Only the cast of a left valve is available to me for description. My determination as *Aviculopecten aff. jabiensi* is based on the fact, that this shell appears to be more nearly allied to this Salt Range species,¹ than to any other form of the present genus. An identification is, however, impossible, Waagen's species itself having been founded on a fragmentary specimen, with only the inside of its left valve preserved.

The general outline of the slightly inflated shell is nearly circular, with continuous margins, and of equal height and breadth. The apex is about median in its position, shifted but very slightly towards the anterior portion of the valve, and but slightly prominent. It is limited on both sides by very unequal wings, the anterior of which is distinctly marked off from the remainder of the shell. The anterior wing is comparatively small, although its exact size cannot be made out, its most prominent portion having been broken off. The posterior wing is very large, nearly flat, and limited on its upper side by a long and straight hinge line. It is broadly emarginated along its posterior margin and terminates in a sharp point, which projects somewhat further than the most prominent point of the posterior shell margin.

The sculpture consists of numerous (20 to 30) radiating ribs, which are broader than the intercostal depressions, separating them. Neither dichotomous, nor intercalated ribs have been observed. They increase considerably in breadth, as they approach the ventral margin. The majority of them seems to be slightly carinate. The two wings are perfectly smooth. Delicate striæ of growth, extending parallel to the margin, are occasionally visible as impressions on the cast.

My specimen is of very small dimensions. Its measurements are as follows:—

Entire length of the shell	11·5 mm.
„ height „ „ „	10 „
Thickness of the left valve	app. 1 „
Length of the hinge line, probably	10·5 „
Apical angle without the wings	about 105° „

Apart from its smaller dimensions, my specimen is very similar to *A. jabiensis*. The two forms agree perfectly well in their most characteristic features, *viz.*, in the outlines, in the general character of the sculpture, and in the development of a very large and pointed posterior wing.

¹ *W. Waagen, Salt Range fossils: Pal. Indica, ser. xiii, I, Productus Limestone fossils, p. 303, Pl. XXIII, fig. 2.*

Slight differences are observed in the details of the sculpture. In particular the apparently carinate shape of the broadly vaulted ribs seems to be absent in the Salt Range species. The left valve of the true *Aviculopecten jabiensis*, moreover, seems to be still less inflated, so far as one may judge from Waagen's figure. In spite of these differences I do not think the specimen under consideration worthy of a proper name, although its identity with *Aviculopecten jabiensis* is improbable. But the discovery of better materials, both of the Himálayan shell and of the Salt Range species, must be awaited for, before anything positive can be stated in this matter.

Number of specimens examined.—1.

Remarks.—Waagen considers *Aviculopecten indianensis*, Meek and Worthen, from the Keokuk group of North America as the probable ancestor of *A. jabiensis*. The single fragmentary specimen, on which the latter species has been founded, was collected by Waagen in the Cephalopoda beds of the upper Productus limestone.

Regarding the generic position of *Aviculopecten* I refer to the description of *A. hiemalis*, Salter, in part 4 of the present volume.

This is the only specimen of lamellibranch in the collections from the limestone crag of Chitichun No. I, which is worth noticing. All the rest are so badly preserved, that no specific description of them can be given.

MOLLUSCOIDEA.

Class : BRACHIOPODA.

Order : TESTICARDINES, Bronn.

Suborder : APHANEROPEGMATA, Waagen.

Family : *PRODUCTIDÆ*, Gray.

Subfamily : *PRODUCTINÆ*, Waagen.

Genus : *PRODUCTUS*, Sow.

The genus *Productus* takes the most important part among the fossils of the permocarboniferous limestone crag of Chitichun No. I, in the number of species, although, as regards the number of individuals, some species of *Athyris* (*Spirigera*) are the most frequent.

There are altogether nine different species, which must be attributed to this genus. Among the subdivisions of *Productus*, established by L. de Koninck, and partly emended by Waagen, five are represented among the fauna of Chitichun No. I, viz. the groups of *lineati*, *semireticulati*, *spinosi*, *fimbriati* and *irregulares*. Although these groups are quite artificial, having been based almost exclusively on

the external sculpture, I am obliged to accept them in the following classification, as I do not know of any other, based on more sound principles.

A classified list of the *Producti*, which have been collected by our expedition in the permocarboniferous limestone crag of Chitichun No. I, is drawn up in the following scheme:—

I. SECTION. LINEATI.

a. GROUP OF PRODUCTUS NEFFEDIEVI, Vern.

1. *P. lineatus*, Waagen.

b. GROUP OF PRODUCTUS CORRUGATUS, M'Coy.

2. *P. Cora*, Orb.

II. SECTION. SEMIRETICULATI.

c. GROUP OF PRODUCTUS SEMIRETICULATUS, Mart.

3. *P. semireticulatus*, Mart.

4. *P. boliviensis*, d'Orb. var., *chitichunensis*, nov. var.

d. GROUP OF PRODUCTUS COSTATUS, Sow.

5. *P. cf. subcostatus*, Waagen.

e. GROUP OF PRODUCTUS PORTLOCKIANUS, Norw. and Pratt.

6. *P. gratiosus*, Waagen.

III. SECTION. SPINOSI.

f. GROUP OF PRODUCTUS CANCRINI, Vern.

7. *P. cancriniformis*, Tschern.

IV. SECTION. FIMBRIATI.

g. GROUP OF PRODUCTUS HUMBOLDTI, Orb.

8. *P. Abichi*, Waag.

V. SECTION. IRREGULARES.

h. GROUP OF PRODUCTUS STRIATUS, Fisch.

9. *P. mongolicus*, nov. sp.

The majority of species, contained in this list, are identical with such, as occur in the *Productus* limestone of the Salt Range, especially in its middle division.

I. Section. LINEATI.

a. GROUP OF PRODUCTUS NEFFEDIEVI, Vern.

1. PRODUCTUS LINEATUS, Waagen. Pl. IV, fig. 2 a-c, 3 a-d, 4 a-d, 5 a-d.

1862. *Productus Cora* (d'Orbigny), Davidson, Quart. Journ. Geol. Soc., XVIII, p. 31.

1876. *P. cora*, (Orb), Trautschold, Die Kalkbrüche von Miatschkowa, Pl. V, fig. 1, p. 53 (syn. exclus).

1884. *P. lineatus*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, *Productus Limestone Fossils*, Pl. LXVI, fig. 1, 2, Pl. LXVII, fig. 3, p. 673.

1889. *P. lineatus*, Tschernyschew, Mem. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 372, Pl. VII, fig. 26, 27.

1890. *P. lineatus*, Nikitin, Mém. Com. Géol. Russ., St. Pétersbourg, V, No. 5, p. 158.

1892. *P. lineatus*, Schellwien, Die fauna des Karnischen Fusulinenkalks, Palæontographica, XXXIX, p. 21, Pl. I, fig. 16-18, III, fig. 1.

This species, which is not rare in the permocarboniferous limestone crag of Chiti-hun No. I, agrees well with the figures and descriptions given by Waagen. As has been pointed out by this learned author, the shells, united formerly under the denomination of *Productus Cora*, may be conveniently divided into two series of forms, one with a median sinus in the visceral region, and another without any median sinus. Our Indian species belongs to the first group, of which *P. Neffedievi* Verneuil (Geologie de la Russie d'Europe, Vol. II, Paleontologie, p. 259, Pl. XVIII, fig. 11) is considered as a prototype.

My specimens vary very considerably in size and outlines. They never attain as large dimensions as Waagen's types from the Salt Range. The largest (Pl. IV, fig. 4) scarcely exceeds in this respect Schellwien's smaller types from the carnian Fusulina limestone. Specimens with an elongately oval outline are quite an exception. As a rule, the length and breadth of the ventral valve are nearly equal. Some of my specimens even exhibit a strongly transverse outline, recalling in this respect the North American *Productus multistriatus*, Meek (Rep. geol. expl. fortieth parallel, Washington, 1877, Pt. I, Palæontology, p. 76, Pl. VIII, fig. 3) from which they differ by their more shallow sinus.

The ventral valve is always strongly inflated. In one of my specimens the lateral parts expand considerably, below the level of the hinge line, as has been described by Trautschold and Waagen in specimens from Russia and the Salt Range.

The median sinus of the ventral valve is never strongly marked, although in the majority of my specimens it is distinctly developed. But there are certainly transitional forms between this species and *P. Cora*, whose only difference seems to be the entire absence of any median sinus. While there are such transitional forms between *Productus lineatus* and *P. Cora* among my specimens, no similar ones seem to exist between the present species and *P. Weyprechti*, Toulà (Kohlenkalk-Fossilien von der Südspitze von Spitzbergen, Sitzgsber. Kais. Akad. Wiss. Wien, math. nat. Cl. LXVIII, November 1873, p. 13, Pl. V, fig. 2, 3, and Kohlenkalk- und Zechstein-Fossilien aus dem Hornsund an der Südwestküste von Spitzbergen, *ibid*, LXX, 1874, p. 6, fig. 4) or *P. impressus*, Toulà (Permocarbon-Fossilien von der Westküste von Spitzbergen, Neues Jahrbuch, 1875, p. 236, Pl. V, fig. 1), in which the median sinus is always considerably deeper, than in any other species of the group of *Productus Neffedievi*.

The sculpture consists of numerous, delicate, radiating, straightly descending striæ, which are occasionally interrupted by irregularly distributed tubercles. It is the presence of these tubercles which serves for a distinction of *P. lineatus* from the very nearly allied *P. Neffedievi*. I am, however, bound to observe, in agreement with Nikitin, that transitional forms between the two species seem to exist, as in some of my specimens the number of tubercles is but very small. Nor is the

concentric sculpture of the wings a constant character, the folds being of a very unequal strength in different specimens and becoming even quite indistinct.

The dorsal valve is not known to me. Nor are the internal characters of the shell accessible in any of my specimens.

The measurements from the largest specimen (fig. 4), are approximately, as follows :—

Length of the shell	. . . . .	24 mm.
Breadth „ „ „	. . . . .	25 „
Length of the hinge line	. . . . .	24 „
Thickness of the ventral valve	. . . . .	12 „

It has been suggested by Nikitin, that the internal characters of the Muscovian types of *P. lineatus* might perhaps differ from those of the Salt Range form. But as Nikitin himself does not give a detailed description of the internal structure of his specimens and, notwithstanding his own statement, accepts *P. lineatus* as interpreted by Waagen, there is, for the present at least, no sufficient reason for a specific separation of the Russian and Indian types of the species.

Number of specimens examined.—8.

Remarks.—*Productus lineatus* is a species of considerable vertical distribution. It has been mentioned by Waagen from the lower Productus limestone, where it is however very rare, from the Virgal and Kalabagh beds of the middle Productus limestone, and from the upper Productus limestone. In Russia the species occurs both in the Muscovian and Gshelian stage of the central coal basin, in the Fusulina limestone of the Ural of upper carboniferous age, and in the permo-carboniferous Artinskian marls. By Schellwien the species is quoted from the Carnian Fusulina limestone of the Krone in Carinthia of upper carboniferous age (Gshelian stage).

b. GROUP OF PRODUCTUS CORRUGATUS, M'Coy.

2. PRODUCTUS CORA, d'Orbigny (*P. PRATTENIANUS*, Norw. and Pratten). Pl. IV, fig. 1.

1842. *Productus Cora*, d'Orbigny, Voyage dans l'Amérique Méridionale, III, pt. iv. Paléontologie, p. 55. Pl. V, figs. 8, 9.

1854. *P. Prattenianus*, Norwood and Pratten, Journ. Acad. Nat. Sci., Philadelphia, ser. ii, III, p. 17, Pl. I, fig. 10.

For list of further synonyms, see Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 677, to which the following must be added :—

1862. *Productus Cora*, Möller, Journal des Mines, St. Pétersbourg, p. 179, Pl. 9, fig. 3.

1866. *P. riparius*, Trautschold, Bull. Soc. Imp. Nat. Moscou, XL, Pl. V, fig. 1.

1889. *P. Cora*, Tschernyschew, Mém. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 282.

1892. *P. Cora*, Schellwien, Die Fauna des Karnischen Fusulinenkalks, Palæontographica, XXXIX, p. 21, Pl. III, fig. 3.

With the present species I identify two ventral valves, which do not exhibit any trace of a median sinus, and by this character differ remarkably from *Productus lineatus*. The presence of a few irregularly scattered spines on the surface marks

my specimens as specifically distinct from *P. corrugatus*, M'Coy (Synopsis of the characters of the Carboniferous Limestone Fossils of Ireland, Pl. XX, fig. 13, p. 107), which otherwise shows the same configuration and the same inflation of the ventral valve. Traces of indistinct spines may also be observed along the hinge line.

My specimens are of nearly equal length and breadth, so far as this can be made out in their incomplete state of preservation. They are provided with tolerably spread out wings. Their hinge line corresponds to the greatest breadth of the shell.

Concentric folds or wrinkles are but quite indistinctly developed. The character of the radiating striæ, which cover the surface of the valve, is exactly the same as in *Productus lineatus*.

The specimens are smaller than the largest types of *P. lineatus* from Chitichun No. I. The figured specimen is about 18 mm. long, 20 mm. broad, and 12 mm. thick, but it is barely possible to give exact measurements, as it has not been preserved entire. Neither the dorsal valve nor the internal characters are accessible to observation.

Number of specimens examined.—2.

Remarks.—Waagen refers the American *Productus prattenianus*, Norw. and Pratt., to the true *P. Cora*, but considers the Russian *Prod. Cora*, Möller, as specifically distinct from d'Orbigny's species. Tornquist (Das fossilführende Unter-carbon am östlichen Rossbergmassiv in den süd-Vogesen, Abhandl. zur geologischen Special-Karte von Elsass-Lothringen, V. Heft 4, Strassburg 1895, p. 52) likewise asserts that the true *P. Cora* is probably altogether wanting in the carboniferous strata of Europe.

The Russian authors, who have been working out recently the description of the younger palæozoic faunas of their country, do not, however, follow this view. Tschernyschew positively asserts that the Russian examples cannot be distinguished from *P. Cora*, and that they will consequently require to be added to the synonyms of d'Orbigny's species.

Productus Cora, if taken with the definition attributed to this form by the Russian geologists, is a species of a rather wide geographical and geological distribution. In Russia, it has been found in the Moscovian stage, in the upper Fusulina limestone of the Ural where it is the leading fossil of a special horizon, and in the Artinskian stage of permocarboniferous age; in America in the coal measures of the Mississippi valley through the whole thickness of which it ranges¹, and in the carboniferous and permocarboniferous strata of Missouri, Nebraska, Yarbichambi (Bolivia), and Itaituba (Brazil); in the Salt Range it occurs off and on through the whole vertical extent of the *Productus* limestone but most numerous at the very base of the fossiliferous lower *Productus* limestone. It has been also obtained by Schellwien from the Carnian Fusulina limestone of upper carboniferous age.

¹ Meek in Cl. King's Exploration of the 40th parallel, Vol. IV, p. 72.

II. Section. SEMIRETICULATI.

C. GROUP OF PRODUCTUS SEMIRETICULATUS, Mart.

3. PRODUCTUS SEMIRETICULATUS, Martin. Pl. II, fig. 1, 3, 5, Pl. III, 1, 2.

1809. *Anomites semireticulatus*, Martin, Petrificata Derbyensia, Pl. XXXII, fig. 1, 2, Pl. XXIII, fig. 4.
1845. *Productus semireticulatus*, de Verneuil, Géologie de la Russie d'Europe, Vol. II, Paléontologie, Pl. XVI, fig. 1, non Pl. XVIII, fig. 9, 10, p. 262.
1847. *Productus semireticulatus*, L. de Koninck, Monographie des genres Productus et Chonetes, Pl. VIII, fig. 1, Pl. IX, fig. 1, Pl. X, fig. 1, p. 83.
1863. *Productus semireticulatus*, Davidson, Monograph of British Carboniferous Brachiopoda, p. 149, Pl. XLIII, fig. 1—11, Pl. XLIV, fig. 1—4.
1874. *Productus semireticulatus*, Meek and Hayden, Final Report of the U. S. Geol. Survey of Nebraska, p. 160, Pl. V, fig. 7.
1874. *P. semireticulatus*, Derby, Carboniferous Brachiopoda of Itaituba, Bull. Cornell University, Ithaca, I, No. 2, p. 47, Pl. IV, fig. 8, Pl. VI, fig. 18, Pl. VII, figs. 5, 6, 7, 15, 16.
1875. *P. semireticulatus*, Toula, Permocarbon-Fossilien von der Westküste von Spitzbergen, Neues Jahrbuch, p. 234, Pl. VI, fig. 1 a, b, c (non d).
1876. *P. semireticulatus*, Trautschold, Die Kalkbrüche von Miatschkowa, Pl. V, fig. 3, p. 56.
1877. *P. semireticulatus*, Meek, Clarence King, Report of the Geological Exploration of the fortieth parallel, Vol. IV, Palæontology, p. 69, Pl. VII, fig. 5.
1883. *P. semireticulatus*, Kayser, Obercarbonische Fauna von Loping, Rieht-hofen's China, IV, p. 181, Pl. XXV, fig. 1—4.
1884. *P. semireticulatus*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone fossils, p. 679, fig. 22 a, b, c.
1889. *P. semireticulatus*, Tschernyschew, Mem. Com. Geol. Russ., St. Pétersbourg, III, No. 4, p. 278.
1890. *P. semireticulatus*, Walther, Ueber eine Kohlenkalk-Fauna aus der ägyptisch-arabischen Wüste, Zeitschr. Deutsche Geol. Gesellsch., XLII, p. 433, Pl. XXVI, fig. 8-11.
1892. *P. semireticulatus*, Schellwien, Die Fauna des Karnischen Fusulinenkalks, Palæontographica, XXXIX, p. 23, Pl. II, fig. 1-3.
1892. *P. semireticulatus*, Rothpletz, Die Perm- Trias- und Jura-formation auf Timor und Rotti, Palæontographica, XXXIX, p. 77.
1894. *P. semireticulatus*, Schellwien, Ueber eine angebliche Kohlenkalkfauna aus der ägyptisch-arabischen Wüste, Zeitschr. Deutsche Geol. Gesellsch. XLVI, p. 70.
1895. *P. semireticulatus*, Tornquist, das fossilführende Untercarbon am ostlichen Rossberg-Massiv in den süd-Vogesen, Abhandlgn. zur Geol. Special-Karte von Elsass-Lothringen, V, Heft 4, p. 60, Pl. XIV, fig. 10, 12.

This well known, extremely characteristic and far spread species of the genus *Productus* is very numerously represented in the permocarboniferous limestone of the Chitichun crag. The preceding list of synonyms might easily have been enlarged considerably, but the quotations given in respect to the present species, are sufficient to prove that it is the true *Productus semireticulatus*, with which my specimens, I believe, must be identified.

Notwithstanding the variability of the shells belonging to this species, their principal features are always sufficiently characteristic, to make their distinction comparatively easy. The majority of the specimens belong to the group of strongly sinuated varieties of *P. semireticulatus*, which in strata of upper carboniferous and permocarboniferous age considerably predominate over the types with a shallow median sinus. Nevertheless the latter shape, which closely resembles the typical form of the species, is not altogether absent. The specimen, figured Pl. III, fig. 2, is a representative of this group, being provided with a very shallow, indistinct depression along the median portion of its ventr valve. This depression extends only as

far as the visceral part, but lower down disappears almost entirely, as in Davidson's type specimen (Pl. XLIII, fig. 1).¹

The shape, which is most frequently met with among my materials of this species from Chitichun No. I, is the specimen figured Pl. II, fig. 1.

In its general outlines it resembles most closely the types of *P. semireticulatus*, collected by F. von Richthofen near Loping and figured by Kayser, or Trautschold's specimen from Miatschkowa, whose dimensions, however, it considerably exceeds. It is transversely oval and is provided with a hinge line, which is shorter than the greatest breadth of the shell. The ventral valve is moderately vaulted. Its auriculate expansions are distinctly developed, but are not produced beyond the lateral margins of the valve. The beak is strongly incurved but overhangs the hinge line but slightly. The apical region is reticulate. The reticulate sculpture extends for a distance of 55 mm. from the apex, measured along the curve, or across two-thirds of the length of the valve, excluding the trail. The radiating ribs, which cover the frontal and lateral parts of the shell, are rather regularly disposed and of nearly equal thickness. There are from 6 to 7 ribs within the space of 10 mm. The larger number of ribs are simple. Bifurcating or intercalated ribs are quite an exception. The number of spines is very limited. All my specimens agree pretty well in this respect. If any spines do occur, it is upon the wings, in the vicinity of the hinge line.

The dorsal valve is moderately concave. A flat median fold corresponds to the sinus in the ventral valve. Its ornamentation is exactly of the same character, as in the specimen figured by Walther from the upper carboniferous limestone of the Egyptian desert (Pl. XXV, fig. 11b).

The majority of the examples, more or less, closely resemble the specimen under consideration. Between this typical form of *P. semireticulatus* from the Chitichun limestone and the rest of the specimens differences are perceptible, with regard to both shape and sculpture. Some of them exhibit a very strong geniculation in the lower portions of the two valves, but in the majority the ventral valve, at least, is simply semicircularly curved. Their outlines are rather variable although not a single one is elongately oval. In one the greatest breadth of the shell is nearly twice its length, whereas in another the difference between these two dimensions is only insignificant.

Another character of variability is the depth of the sinus. The presence of forms with a shallow sinus, recalling the typical form from the carboniferous limestone of Belgium and England, has been mentioned in the preceding description of the species. Between this form (Pl. III, fig. 2), and the specimen, figured Pl. III, fig. 1, every degree of intermediate shapes may be observed. The latter example is characterised by its extraordinarily deep sinus. In this respect it may be compared to *P. semireticulatus* var. *bathykolpos*, Schellwien (Palæontographica, XXXIX, 1892, Pl. II, fig. 4-10, p. 22), from the upper carboniferous Fusulina

¹ Similar specimens have been mentioned by Kirkby from the coalmeasures of Fife as *Productus semireticulatus* var. *Martini*. (On the occurrence of marine fossils in the coalmeasures of Fife; Quart. Journ. Geol. Soc., London, XLIV, 1888, p. 750).

limestone of the Carnian Alps. But the smaller size, which Schellwien considers to be a constant character of the Carnian variety, is a point of difference between the latter and my Tibetan specimen.

The ornamentation varies with regard to both the width of the ribs and the interspaces between them. In an average sized specimen about 50 ribs may be counted on the frontal and lateral parts of the ventral valve, 5 to 8 occupying the space of 10 mm.

The dimensions of the species are also extremely variable. The largest specimen is 55 mm. in length, and 55 mm. in breadth. The average size of the specimens from Chitichun No. I is represented in Pl. II, fig. 1. The measurements of this specimen are as follows:—

Length of the shell in a straight line	. . . . .	47	mm.
" " " along the curve	. . . . .	80	"
Breadth of the shell	. . . . .	61	"
Length of the hinge line	. . . . .	app. 56	"
Thickness of the ventral valve	. . . . .	26	"

In this specimen the trail has not been preserved.

Number of specimens examined.—20.

Remarks.—I scarcely need dwell upon the importance of *Productus semireticulatus* as a fossil of uncommonly wide geographical distribution. Unfortunately its geological range is scarcely less extended, as it ranges from the subcarboniferous rocks of North America and from the mountain limestone of Western Europe through the carboniferous system into permocarboniferous and probably even permian strata (Timor). From the predominance of forms, provided with a deeply impressed median sinus, in upper carboniferous and permocarboniferous strata the myth has originated, that the form with a shallow sinus, which is most frequently met with in the mountain limestone, is replaced by the sinuated variety in younger horizons. But the examination of my materials from Chitichun No. I gives evidence to the contrary, forms with a shallow sinus and strongly sinuated types being indiscriminately mixed together in this permocarboniferous fauna.¹

4. *PRODUCTUS BOLIVIENSIS*, d'Orbigny, NOV. VAR., CHITICHUNENSIS.

Pl. II, fig. 2, 4.

1892 (?) *Productus sp. ind.*, Rothpletz, Die Perm- Trias- und Jura-formation auf Timor und Rotti, Palæontographica, XXXIX, p. 77, Pl. X, figs. 17, 18.

Much difference of opinion has been expressed as to the specific value of *Productus boliviensis*, Orb. (Voyage dans l'Amerique Meridionale, III, pt. 4, Palæontologie, p. 52, Pl. IV, fig. 5-9). Some have considered it as only a variety of *P. semireticulatus*, whereas L. de Koninck, Tschernyschew and Nikitin maintained it as a separate species. As characters, which may serve for a distinction of the two closely allied forms, the strong curvature in the profile of the spirally inrolled

¹ As has been mentioned before, specimens of *P. semireticulatus*, which are devoid of any sinus, have been described by Kirkby from the coalmeasures of Fife, of upper carboniferous age.

ventral valve, the deep sinus, the transversely elongated shape, and the presence of the distinctly defined, strongly dilated ears have been enumerated by L. de Koninck (Mem. Soc. Roy. Sci., Liège, IV, p. 177, Pl. VIII, fig. 2, and Monographie des genres *Productus* et *Chonetes*, p. 77, Pl. VIII, fig. 2 a, b, c), who based his diagnosis on d'Orbigny's type specimen from Yarbichambi (near lake Titicaca).

The last mentioned character seems to be the most important one. Schellwien (Palæontographica, XXXIX, p. 23) lays a special stress on this remarkable feature, although he quotes *P. boliviensis* only among the varieties of *P. semireticulatus*. Nikitin (Mém. Com. Géol. Russ., St. Pétersbourg, 1890, V, No. 5, p. 57) likewise considers the "very large wings," combined with the involute shape and the deep sinus, a character of specific value, which permits the separation of *P. boliviensis* from *P. semireticulatus*. Grunewaldt (Beiträge zur Kenntniss der sedimentären Gebirgsformationen etc. Mém. Acad. Imp. Sci., St. Pétersbourg, 1860, ser. vii, II, No. 6, p. 119) in his description of a *Productus* from Saraninsk, which he identifies with *P. semireticulatus*, expressly remarks, that this form is distinguished from Martin's species by distinctly defined, strongly expanding ears, a character which has never been detected in the true *P. semireticulatus*. He further states that he would undoubtedly have compared this Russian form to *P. boliviensis*, had not the presence of transitional types between the former and the true *P. semireticulatus* prevented him from doing so.

Thus palæontologists are far from unanimous with reference to the specific or varietal rank of *P. boliviensis*. I am, however, inclined to believe that both L. de Koninck and Nikitin are substantially correct in separating this species from *P. semireticulatus*, on account of its remarkably well developed auriculate expansions, whereas the other characters of distinction, enumerated by the above-mentioned authors, appear to me of only somewhat slight importance.

Among the material from Chitichun No. I a considerable number of specimens are I think, most nearly allied to d'Orbigny's *P. boliviensis*. They differ from *P. semireticulatus*, which is, however, the more common species in the Chitichun crag, by their smaller size, the strongly transverse shape, a more delicate sculpture, but especially by the presence of unusually expanded ears. The ears are more or less distinctly marked off from the remainder of the shell and recall the wings of *P. giganteus*, Mart. They are inflated, slightly emarginated and obtusely rounded at their extremities.

Both the curvature of the profile and the depth of the sinus are as variable as in *P. semireticulatus*. The ventral valve, figured Pl. II, fig. 4, resembles closely Nikitin's type specimen from Gshel. (loc. cit. Pl. I, fig. 4). It is strongly inrolled, with a slightly flattened space not far from the apex, which extends almost as far as the reticulate portion of the valve. It is provided with a deep median sinus, whose shape seems to have been somewhat altered by pressure, and with a distinctly prominent beak. In the specimen, figured Pl. II, fig. 2, the profile of the ventral valve is less strongly curved, and the sinus but shallow. The unusually expanded ears recall the figures of *P. giganteus*, given by L. de Koninck on Pl. II of his monograph of the genera *Productus* and *Chonetes*.

A third specimen is much more strongly inflated than the two figured types. Its ventral valve is regularly vaulted, and of a simple semiglobose shape, like d'Orbigny's type specimen of *P. boliviensis*, or the Russian examples from Saraninsk, described and figured by Grünewaldt (loc. cit. Pl. III, fig. 1).

In the Tibetan specimens the sculpture is much more delicate than in types of *P. semireticulatus* of the same size, and also more delicate than in any of the figures, which have hitherto been given, of *P. boliviensis*.

The longitudinal ribs are less thick than in Nikitin's type specimen from Gshel. They occur to the number of 12 to 15 to a space of 10 mm. at least in the vicinity of the front margin, where they augment considerably, mostly by bifurcation. In the reticulate portion of the valve about ten longitudinal striæ occupy a breadth of 10 mm. They are but slightly surpassed in width by the concentric wrinkles. The longitudinal ribs are occasionally flexuous. The spines are irregularly scattered on the surface of the shell and of unequal size.

The large number of longitudinal striæ, which, according to the figures given by L. de Koninck and Nikitin, do not seem to agree with the true average characters of d'Orbigny's species, may be found a sufficient reason for distinguishing my Tibetan examples by a proper varietal denomination. I think, the name *P. boliviensis* var. *chitichunensis* might be advantageously retained for them, in order to mark their sufficiently well defined differences from d'Orbigny's typical form.

The dorsal valve is strongly concave. A shallow median fold is not always present. Both in its shape and sculpture it is very similar to the dorsal valve in *P. semireticulatus*.

The measurements from the specimen Pl. II, fig. 4, which are however approximate only, on account of its incomplete state, are as follows:—

Length of the shell in a straight line	app.	25	mm.
" " along the curve	"	55	"
Greatest breadth of the shell	"	58	"
Thickness of the ventral valve	"	19	"

The internal characters of this species are not known to me, nor can I find any notice of them in the descriptions of the abovementioned authors.

Number of specimens examined.—6.

Remarks.—In his monograph of the permian and mesozoic fossils from Timor, Rothpletz described and figured two specimens of a *Productus*, which certainly belong to the section of *semireticulati*, but differ from the true *P. semireticulatus* by their much more delicate ornamentation, 12 to 16 radial striæ occupying a space of 10 mm., *i.e.*, nearly twice as many as in Martin's species. Rothpletz, although considering this *Productus* to be a proper species, quotes it only as *Productus sp. ind.* on account of the incomplete state of his specimens. I am inclined to believe that this species may prove identical with my Tibetan variety of *P. boliviensis*, but the fragments from Timor are too imperfectly preserved to establish their identity with full certainty.

The geographical and geological distribution of the true *P. boliviensis* is but imperfectly known. The species has been mentioned from the coalmeasures of

Yarbichambi in Bolivia and of Missouri (Norwood and Pratten), from the upper carboniferous limestone of Central Russia and of the Ural Mountains (Tschernyschew), and from the Artinskian horizon of permocarboniferous age.

d. GROUP OF *PRODUCTUS COSTATUS*, Sowerby.

5. *PRODUCTUS cf. SUBCOSTATUS*, Waagen. Pl. II, fig. 6 *a, b, c.*

1884. *Productus subcostatus*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 685, Pl. LXVII, figs. 4, 5, Pl. LXVIII, figs. 1, 2, Pl. LXIX, fig. 4.

The rather badly preserved cast of a dorsal valve with a portion of its trail which is alone available for description, agrees pretty well with the figures of the present species, as given by Waagen. An identification is however not possible, on account of the insufficiency of the material.

As it is the cast of the valve which is represented in the figure, its shape and sculpture are just the reverse of what they would be if the shell were visible from the outer side. If we describe it as from the outer side of the shell, it exhibits a transversely elongated, regularly concave shape, with a blunt geniculation marking off the trail from the remainder of the valve. A median fold is distinctly developed in the frontal region of the visceral part and extends over the trail, apparently corresponding to a deep and rather narrow sinus in the ventral valve.

The wings are flat and distinctly separated from the visceral part. They are covered with concentric wrinkles, which contrast sharply with the strong radial plications of the trail. There are 28 radial ribs present. The visceral part of the valve is strongly reticulate. The figure 6c gives a tolerably clear idea of this sort of sculpture. The deep grooves along the inner margin of the wings, which Waagen considers to be the most singular feature in the dorsal valve of *P. subcostatus*, are distinctly indicated.

As the present shell agrees in every respect with *P. subcostatus*, I think myself justified in provisionally attributing it to Waagen's species, without venturing however to pronounce it identical with the latter.

Remarks.—*P. subcostatus* has been collected by Waagen in the Virgal beds of the middle Productus limestone and in the Khund ghat beds of the upper Productus limestone of the Salt Range. It is a rare species and has not as yet been discovered outside the Punjab.

e. GROUP OF *PRODUCTUS PORTLOCKIANUS*, Norw. and Pratt.

6. *PRODUCTUS GRATIOSUS*, Waagen. Pl. III, figs. 3—7.

1865. *Productus semireticulatus* (Mart.), Beyrich, Ueber eine Kohlenkalkfauna von Timor, Abhandlg. K. Akad. Wiss. Berlin, 1864, Pl. II, fig. 2.

1884. *Prod. graciosus*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 691, Pl. LXXII, figs. 3—7.

1892. *Prod. gratiosus*, Rothpletz, Die Perm-Trias- and Jura-formation auf Timor und Rotti, Palæontographica, XXXIX, p. 76, Pl. X, fig. 15.

1892. *Prod. gratiosus* var. *occidentalis*, Schellwien, Die Fauna des Karnischen Fusulinenkalks, Palæontographica, XXXIX p. 27, Pl. III, fig. 6-9, Pl. VIII, fig. 25.

This elegant species is one of the most common types of the genus *Productus* in the permocarboniferous limestone of Chitichun No. I. The figures given on Pl. III of this memoir show on the one hand the absolute identity of the Tibetan and Salt Range specimens, and on the other hand the great variability of the species.

The largest specimen (fig. 5) is exactly of the same size as the largest type of this species which Waagen has met with from the *Productus* limestone of the Punjab. But in the Chitichun crag, as in the Salt Range or in the permian rocks of Timor, specimens of so large dimensions are quite the exception.

Regarding the general characters of *P. gratiosus*, which can scarcely be confounded with any other species of the genus, I have but very little to add to Waagen's description.

The ventral valve is always strongly inflated, slightly geniculated, and provided with a deep but comparatively narrow sinus, which originates in the immediate vicinity of the apex. In one of my specimens (fig. 7) the sinus is extraordinarily deep, considerably deeper than in any of the types from the Punjab. The ears are small, but distinctly defined, if they have been preserved at all, which is however rarely the case. The delicate reticulation is confined to the apical region. The strongly profiled radial ribs converge towards the mesial sinus and bifurcate rather frequently. The specimen fig. 6 is a good example of this sort of sculpture. The spines are very thin and numerous, but can only be observed in perfectly preserved specimens (fig. 4). On the casts the place of insertion of the spines is marked by small grooves, resembling the impressions of a sharp needle (fig. 3).

The dorsal valve is concave and provided with a prominent median fold. The reticulation extends considerably nearer to the front than in the ventral valve. The fan shaped character of the longitudinal ribs is very well exhibited in the figured specimen (fig. 3).

The measurements of my largest specimen are as follows:—

Length of the shell in a straight line	27 mm.
" " " " along the curve	58 "
Breadth of the shell	22 "
Thickness of the ventral valve	17 "

Notwithstanding the great variability of my specimens, there is not a single one among them, agreeing with *P. gratiosus* var. *occidentalis*, Schellw., from the Carnian Alps. The prominent ridges, which in the Carnian types mark off the wings from the remainder of the ventral valve, have not been noticed in my Tibetan shells. Thus the Alpine variety seems to be distinguished from the typical form of the species by a constant, though rather subordinate character.

Number of specimens examined.—21.

Remarks.—*Productus gratiosus* is most numerously represented in the middle division of the Salt Range *Productus* limestone. It is rare, both in the Katta beds:

and in the upper *Productus* limestone. In the lower *Productus* limestone it has not been discovered. Rothpletz recognised the species among the permian fossils from Timor. A variation of the true *P. gratiosus* has been collected by Schellwien in the upper carboniferous *Fusulina* limestone of the Carnian Alps.

The affinities of our species to *P. portlockianus*, Norw. and Pratt., *P. longispinus*, Sow., *P. griffithianus*, de Kon., and *P. costatus*, Sow., have been fully discussed by Waagen, Schellwien and Rothpletz. Regarding this subject I consequently refer to the monographs of these authors quoted above.

III. Section. SPINOSI.

f. GROUP OF *PRODUCTUS CANCRINI*, Verneuil.

7. *PRODUCTUS CANCRINIFORMIS*, Tschernyschew. Pl. IV, figs. 6 a, b, 7 a-d.

1889, *Productus cancriniformis*, Tschernyschew, Allgemeine geologische Karte von Russland, Blatt 139, Beschreibung des Central Ural und des Westabhanges, Mém. Com. Geol. Russ., St. Pétersbourg, III, No. 4, p. 373, pl. VII, figs. 32, 33.

1896. *P. cancriniformis*, Diener, Pal. Indica, ser. xv, Himálayan Fossils, I pt. iv. The permian fauna of the *Productus shalas*, etc., p. 31, Pl. I, figs. 7-10.

For a complete list of synonyms I refer to this memoir.

This characteristic species is represented in my collection from Chitichun No. I by two incomplete ventral valves, agreeing very well with Tschernyschew's type specimens, for the loan of which I am greatly indebted to Professor Th. Tschernyschew of St. Petersburg. They are of the same size as the latter, and are considerably larger than the average sized specimens from the Himálayan *Productus* shales.

The better preserved of my two examples particularly resembles in its shape and sculpture Tschernyschew's type specimen from the Bijas River (fig. 33). Their only difference consists in the larger number of the wrinkled, concentric folds, which extend from the wings and lateral margins across the entire shell. Otherwise the ornamentation is of exactly the same pattern, consisting of numerous delicate striæ and elongated spines. A few small erect spines are placed along the hinge line. A median sinus is completely absent.

In my second specimen the surface has been more strongly weathered. In its sculpture therefore the concentric wrinkles remain as the only predominant features.

I do not hesitate to identify these specimens with *P. cancriniformis*, although, without the knowledge of the dorsal valve, it is rather difficult to make their determination with sufficient accuracy. There is especially one species in the American coalmeasures of Nebraska, which strongly resembles *P. cancriniformis*, and this is *P. pertenuis*, Meek and Hayden (Final Report of the U. S. Geol. Survey of Nebraska, p. 164, Pl. I, fig. 14, Pl. VIII, fig. 9). According to Tschernyschew, the two species can be distinguished only by the shape of the dorsal valve, which is flat and strongly geniculate in *P. cancriniformis*, whereas it is strongly curved in *P. pertenuis*. Nevertheless I am not inclined to assign my specimens from Chitichun to the American species. *P. pertenuis* is always small, the largest specimens reaching a length of about 15 mm. only, whereas in my specimens the entire length of the shell is more

than 20 mm. Nor are the concentric wrinkles so strongly defined in any of the types figured by Meek and Hayden as in *P. cancriniformis*.

If the larger number of concentric folds should prove a constant character in the form from Chitichun No. I, it may be considered desirable to distinguish it from the typical *Prod. cancriniformis* by a varietal denomination. For the present, however, this difference appears to me of too small importance to make the shell under description a distinct variety.

The measurements of the more complete specimen (fig. 7) are the following :—

Length of the shell in a straight line	24 mm.
” ” ” along the curve	43 ”
Breadth of the shell	24 ”
Thickness of the ventral valve	11 ”

Number of specimens examined.—2.

Remarks.—Tschernyschew's type specimens of this characteristic species were obtained from the Artinskian horizon of the Ural Mountains. Schellwien mentions it from the upper carboniferous Fusulina limestone of the Carnian Alps in Carinthia. It is a common fossil in the permian Productus shales of the Central Himalayas. In Central Asia it has been collected by Bogdanowitsch in the brachiopod bearing limestone near the Gussass River (Western Kwen Lun) of permocarboniferous or permian age.

IV. Section. FIMBRIATI.

g. GROUP OF PRODUCTUS HUMBOLDTI, d'Orb.

8. PRODUCTUS ABICHI, Waagen. Pl. III, fig. 8 a-d.

1862. *Productus Humboldti*, (d'Orb.) Davidson, Quart. Journ. Geol. Soc., London, XVIII, p. 32, Pl. II, fig. 6.
1863. *P. Humboldti*, (d'Orb.) Davidson in L. de Koninck, Mémoire sur les fossiles paléozoïques recueillis dans l'Inde, p. 39, Pl. XII, fig. 6.
1878. *P. scabriculus* (Martin) Abich, Geologische Forschungen in den Kaukasischen Ländern, Bd. I, Ueber eine Bergkalk fauna aus der Araxes-Enge bei Djoulfa, p. 33, Taf. V, fig. 3.
1879. *Strophalosia horrescens*, (Vern.) v. Möller, Ueber die bathrologische Stellung des jüngeren paläozoischen Schichtensystems von Djoulfa in Armenien, Neues Jahrbuch, p. 233, 234.
1883. *Productus Humboldti*, (d'Orb.) Lydekker, Geology of the Kashmir and Chamba Territories and of the British district of Khághán, Mem. Geol. Surv. Ind., XXII, Pl. II, fig. 3.
1884. *P. Abichi*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I Productus Limestone Fossils, p. 697, Pl. LXXIV, fig. 1-7.
1892. *P. Abichi*, Rothpletz, Die Perm-Trias- und Jura-formation auf Timor und Rotti, Paläontographica, XXXIX, p. 76, pl. X, fig. 20.

This species, which has been excellently described by Waagen, is represented in the materials from Chitichun No. I, by two ventral valves, the smaller of which, though slightly weathered, is sufficiently well preserved to allow its identification with certainty.

The specimen under consideration is rather strongly inflated, recalling in this respect the one figured by Waagen, Pl. LXXIV, fig. 7. It is but slightly broader than long, provided with a distinct median sinus and with very small barely flattened wings. From the latter the sides ascend rather abruptly to the flattened visceral portion of the valve. The hinge line is considerably shorter than the greatest breadth of the shell. The apex is attenuated, strongly bent over, but scarcely overhanging the hinge line.

The sculpture exhibits the characteristic quincuncial arrangement of the numerous, coarse, elongated and club shaped tubercles, which is a peculiar feature of this elegant species. The difference in the ornamentation of the visceral portion and of the lateral parts of the valve is not so strongly marked in my two specimens as in the majority of Waagen's types from the Salt Range. In the larger of my specimens, which is, however, only an internal cast with its surface deteriorated by weathering, numerous and strong, imbricating striæ of growth are developed near the lateral and frontal margins. In the smaller specimen this concentric sculpture is confined to the frontal portion of the valve.

The measurements of this latter specimen are as follows:—

Length of the valve in a straight line	27 mm.
„ „ „ „ along the curve	49 „
Greatest breadth of the valve	30 „
Thickness of the valve	14 „
Length of the hinge line	20 „

In my monograph of the fauna of the permian Productus shales of the Central Himálayas (Vol. I, Pt. 4) a species has been described under the denomination of *Prod. gangeticus* (Pl. I, fig. 1-3; Pl. II, fig. 3), the ventral valve of which most perfectly agrees with that of *P. Abichi* in shape and sculpture. As the differences between the two species consist in the shape and in the internal characters of the dorsal valve, the larger size of *P. gangeticus* is a good character, which may serve for a distinction, if one has to deal with ventral valves only. My specimens are of the average size of *P. Abichi*, and I therefore believe to be justified in identifying them with the latter species.

Number of specimens examined.—2.

Remarks.—*Productus Abichi* is a characteristic fossil of the middle and upper divisions of the Salt Range Productus limestone. It has been collected by Waagen both in the Virgal and Kalabagh beds, but not in the Katta beds of the middle Productus limestone. It is known from the permian rocks of Julfa in Armenia and of the island of Timor, and does not seem to descend into strata of upper carboniferous age. The stratigraphical position of the beds in Kashmir, where the species has been collected by Lydekker, is yet doubtful. A discussion of this subject will only be possible after the fossils from Kashmir have been described in detail.

V. Section. IRREGULARES.

h. GROUP OF PRODUCTUS STRIATUS, Fisch.

9. PRODUCTUS MONGOLICUS, nov. sp. Pl. IV, fig. 8, 9, 10.

1883. *Productus cf. Cora* (Orb), Kayser, Obercarbonische Fauna von Loping, Riechthofen's China, IV, p. 184. Pl. XXVII, fig. 5.

A shell belonging to this species has been described by Kayser from the upper carboniferous beds of Loping in China, but has been provisionally united with *Prod. cora*, although this author himself was apparently aware of the remarkable differences which forbid an identification with d'Orbigny's well known species. In his description he correctly mentions the pointed shape of the beak, recalling that of *P. striatus*, and the presence of concentric wrinkles crossing the visceral portion of the ventral valve, as characters which have never been observed in the true *Prod. Cora*. He, however, believed, that the general features of the relief of his solitary specimen could not be much relied upon, as it seemed to have been a good deal altered by pressure, and he consequently considered his material too scanty for establishing a new species.

In 1884 Waagen described two very similar forms from the Productus limestone of the Salt Range, which had been originally united with *P. striatus* by Davidson, as *Prod. compressus* and *P. mytiloides*, and arrived at a satisfactory determination of the systematic position of the Chinese shell among the *Producti*.

Among the materials from the permocarboniferous limestone crag of Chitichun No. I, there are a few specimens, which, in my opinion, are identical with Kayser's *P. cf. Cora*. As this species must receive a new denomination, I introduce the name of *P. mongolicus*. There are fairly complete ventral valves and the fragment of a dorsal valve accessible to observation.

The general shape of the species is nearly triangular, elongated, with an acuminate apex and a rounded front margin. The ventral valve is either strongly inflated, as in the specimen fig. 8, or somewhat flattened, as in the specimen fig. 9. The curve is more regular in the transverse than in the longitudinal direction. In the latter it is less strongly vaulted, especially so in the vicinity of the apical region.

In the specimens figs. 9 and 10, the trail is marked off from the remainder of the shell by a blunt geniculation. The wings are small, but distinctly developed, though rarely preserved. They are bent down almost vertically, leaving barely any room for the development of a straight hinge line, which, properly speaking, does neither exist in this species, nor in the very nearly allied *P. compressus*, Waagen (Pal. Indica, ser. xiii, I, p. 10, Pl. LXXXI, fig. 1, 2). The apical region is strongly compressed and terminates in a distinctly incurved, slightly prominent and pointed beak. A mesial sinus is entirely absent. The median portion of the valve is always strongly convex.

The sculpture is very characteristic. It consists of delicate, radiating striæ, which are crossed by broad, prominent, concentric wrinkles.

The longitudinal striæ increase in number considerably by the interpolation of other striæ which spread out in a very regular manner, always meeting the lateral and front margins at right angles. By means of a magnifying glass a system of extremely delicate transverse striæ may be noticed, which cross the radiating sculpture, and are clustered together very closely, exactly as has been represented by Kayser in fig. 5b on Pl. XXVII of his memoir. The concentric wrinkles are by far the most conspicuous feature in the ornamentation of this valve. They are tolerably regular, obtusely rounded on their tops, and imbricating towards the apical region. They are not restricted to the median portion of the valve, as in *P. compressus*, but extend across the wings. A few scattered spines are confined to the wings and to the lateral parts in their vicinity.

The shell is extremely thin and fragile.

The dorsal valve is distinctly concave, following the curve of the opposite one and leaving but very little room between them. As far as I can judge from the fragment at my disposal, its ornamentation is similar to that of the ventral valve.

The measurements of the smallest of the specimens, which is, however, fairly complete, are the following :—

Length of the shell in a straight line	21 mm.
" " " " along the curve	27 "
Breadth of the shell	16 "
Thickness of the ventral valve	12 "
Approximate distance of the two valves from each other	2 "

Of the internal characters of the species nothing is known to me.

Number of specimens examined.—3.

Remarks.—The identity of the Tibetan species with Kayser's specimen from Loping may best be proved by a comparison of the drawings. They agree in every respect, even in the minor details of their sculpture.

In its general appearance this species approaches very nearly *Prod. compressus* Waagen from the middle and upper Productus limestone of the Salt Range. The points of difference between the two forms are of a comparatively small importance. The absence of any transverse sculpture on the wings and the smaller size of the concentric wrinkles in *P. compressus* are the most conspicuous ones. As a remarkable feature in *P. compressus*, the following is mentioned by Waagen. The ventral valve is always so strongly compressed in the apical region, that in a view from above the lateral margins are concealed below the overhanging lateral parts of the valve. This character has not been noticed in any of my specimens.

From *Prod. mytiloides*, Waagen (Pal. Indica, ser. xiii, I, p. 711, Pl. LXXX, fig. 4) which is very closely allied to *P. compressus*, our species differs by its larger wings and more prominent sculpture. From *P. striatus*, Fisher,¹ a common mountain limestone fossil in England and Belgium, it is distinguished by the same characters, which led Waagen to the introduction of his two new species from the Salt Range.

¹ *L. de Koninck*, Monographie des genres *Productus* et *Chonetes*, Pl. I, fig. 1, p. 30. *Davidson*, Monograph of the British Carboniferous Brachiopoda, p. 139, Pl. XXXIV, figs. 1-5.

Subgenus: MARGINIFERA, Waagen.

1884. *Marginifera*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 713.

In his monograph of the Productus limestone Brachiopoda Waagen introduced the name *Marginifera* as a generic designation for such species of *Productidæ*, as are distinguished from the true *Producti* by a strange chambering of the visceral part of their shells, produced by prominent shelly ridges, placed vertically on the internal surface of the dorsal and within the wings of the ventral valve.

He admitted the occasional presence of similar internal ridges in some specimens of *Productus longispinus*, Sow., and of *P. proboscideus*, Vern., but insisted on the development of these ridges never being anything like that occurring in the shells of the Salt Range. The strong development of the ridges, by which in the latter species the visceral part of the shell is girt, seems to him "perfectly sufficient for the generic distinction of these forms. Certainly it is as well worthy of notice as the existence of an area in *Aulosteges* or the like."

Representatives of this new genus were recognised by him outside the Salt Range only in the permian beds of Julfa (*Marginifera spinosocostata*, Abich, and *M. helica* Ab.), and in the North American coalmeasures of Illinois, Missouri and Indiana (*M. splendens*, Norw. and Pratt).

Tschernyschew (Mém. Com. Géol. Russ., St. Pétersbourg, 1889, III, No. 4, p. 373—375) accepted Waagen's new genus and proved it to be rather largely represented in the upper carboniferous deposits of the Ural. Nikitin (Mém. Com. Géol. Russ., St. Pétersbourg, 1890, V, No. 5) however entirely differs from Waagen and Tschernyschew in the interpretation of the species, which the latter authors united in the genus *Marginifera*. In his opinion the development of circular ridges near the line of contact of the two valves is a character of only very small importance. This character has been mentioned, moreover, in different species of true *Producti*, as in *P. semireticulatus*, Mart., or in *P. longispinus*, Sow., and might probably have been found in many other species of *Productus* if any attention had been paid to it by previous authors. It is a very common character in the Russian shells, which have been identified with *Prod. longispinus* by Trautschold. But the most important evidence against a generic value of these ridges is the fact that they are no constant character in specimens from the same locality and geological horizon, which are perfectly identical in every other respect. Nikitin therefore believes that these ridges indicate a difference of age of the individuals, and not a generic distinction.

Schellwien, who in his monograph of the Brachiopoda from the Carnian Fusulina limestone (Palæontographica, XXXIX, 1892) had accepted Waagen's genus *Marginifera* and had introduced a new species, *M. pusilla*, has lately given up this view on the strength of Nikitin's observations.¹

¹ E. Schellwien, Ueber eine angebliche Kohlenkalk Fauna aus der ägyptisch-arabischen Wüste, Zeitschr. deutsche geol. Ges., XLVI, 1894, p. 70.

Notwithstanding Nikitin's arguments, I prefer to adopt Waagen's view and to claim at least a subgeneric rank for the species united by the latter author in his genus *Marginifera*.

It must be admitted that the peculiarities, which have been considered by Waagen as of generic value in *Marginifera*, are occasionally developed in true *Producti*, but it is likewise true that in none of them, with the possible exception of *Productus longispinus*, Sow., their development is anything like that in a typical *Marginifera*. The internal ridges in specimens of *P. semireticulatus* var. *Martini*, Davidson (Monograph of the British Carboniferous Brachiopoda, Pl. XLIII, fig. 8-10), to which Nikitin alludes, cannot be compared for a moment with those in any Indian *Marginifera*. Nor can I accept, from my own personal examination of Himálayan *Marginifera*, Nikitin's supposition that the internal ridges indicate a difference of age between single individuals. Having examined about 20 specimens of *Marginifera typica* from Chitichun No. I, I came to the conclusion that these ridges are a perfectly constant character in individuals of every size, and that in this species at least they are a feature, which marks not a certain stage of growth, but a distinction between this species and true *Producti*.

That a large number of the Russian forms, united with *Productus longispinus* by Trautschold are provided with internal ridges, as distinctly developed as in any *Marginifera* from the Salt Range or from the Ural Mountains, is no decisive argument against the generic or subgeneric rank of *Marginifera* itself. It simply proves that this genus (or rather subgenus, as I should prefer to consider it) is largely represented among the carboniferous *Productidæ* of Central Russia, as indeed has been clearly recognised by Tschernyschew, although this fact was not known to Waagen at the time when he was publishing his monograph of the *Productidæ* of the Salt Range *Productus* limestone.

The only important evidence against a generic or rather subgeneric value of the internal ridges in *Marginifera* is Nikitin's statement "that, having broken many specimens of the so called *Productus longispinus* from different Russian localities, he found the presence of the ridges to be a very inconstant character, even in specimens from the same locality and geological horizon, in specimens otherwise perfectly identical, in their outlines, generic and specific features."

The importance of this argument must not, however, be overrated. It must be borne in mind, that within the family of *Productidæ* the generic distinctions are altogether difficult and the limits of the different genera rather uncertain on account of the existence of transitional forms. The characters which are used for a generic distinction in this family do not make their appearance suddenly, but are developed by degrees. Thus in this family transitional forms are met with rather frequently, which barely allow a satisfactory determination of their generic position. *Productus*, *Aulosteges*, *Strophalosia*, *Chonetes*, *Productella*, *Daviesiella*, *Chonetella*, *Proboscidella*, *Ætheridgina*, *Aulacorhynchus*, seem to bear scarcely a less intimate relation towards each other, than *Marginifera* does towards *Productus*; so that it is not wonderful that transitional forms should be met with between *Productus* and *Marginifera*, in which the subgeneric characters of the latter have not yet been

sufficiently developed to mark a constant feature. But I do not think that the existence of such transitional forms ought to preclude the establishment of a separate subgenus for such species, in which the subgeneric characters of *Marginifera* have become a constant feature.

There can be no doubt that in the overwhelming majority of *Producti* no internal ridges are present similar those in a true *Marginifera*. It will therefore be found convenient to separate these forms, which bear in each valve a projecting shelly ridge, from *Productus*, and in this way to restrict the latter genus, which already includes a larger number of species than may be conveniently dealt with. Nor is the subgenus *Marginifera* difficult to recognise, if attention is paid to its leading character only, the broken-off shell margin disclosing at once the presence of the prominent internal ridges, especially in the vicinity of the wings.

The distinction between *Productus* and *Marginifera* is not based, it is true, on such conspicuous characters as in many genera of brachiopods, and there always will remain forms, whose systematic position is rather doubtful. But this case is certainly not worse than in other classes of *Molluscoidea* or *Mollusca*. Those who have had to describe *Ammonoidea* or *Gastropoda* will undoubtedly have felt the difficulty in the distinction of genera or subgenera, but notwithstanding this difficulty these genera are maintained, and often on the ground of less striking differences than those existing between *Productus* and *Marginifera*. Among the *Ammonoidea* especially many genera have been recently established, which are so closely related to each other, that they may be considered with nearly equal reason as different stages of development only of one and the same group of forms. Though the limits of the different genera may become continually more difficult to trace, these distinctions must be made so long as the tendency to a narrower restriction of single species and genera prevails among modern palæontologists.

In the permocarboniferous limestone crag of Chitichun No. I, *Marginifera* is represented by a single species, which is identical with one of the most common forms of this subgenus in the middle and upper divisions of the Salt Range *Productus* limestone.

1. MARGINIFERA TYPICA, Waagen. Pl. IV, fig. 11, 12, 13, Pl. V, fig. 1, 2.

1862. *Productus longispinus* (Sow.), Davidson, Quart. Journ. Geol. Soc., London, XVII, p. 31, Pl. I, fig. 19.
 1863. *Productus longispinus* (Sow.), Davidson, in L. de Koninck, Mémoire sur les fossiles paléozoïques recueillis dans l'Inde, p. 37, Pl. X, fig. 19.
 1884. *Marginifera typica*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, *Productus* Limestone Fossils, p. 717, Pl. LXXVI, figs. 4-7; Pl. LXVIII, fig. 1.
 1889. *M. typica*, Tschernyschew, Allgemeine geologische Karte von Russland, Blatt 139, Beschreibung des Central-Urals und des Westabhanges, Mém. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 374, Pl. VII, fig. 22, 23, 24, 28.

The Tibetan specimens agree perfectly with Waagen's species both in their general shape and sculpture, and in the strongly marked development of the internal ridges.

The ventral valve is very strongly inflated, almost spirally inrolled in the

majority of the specimens. The curve is, as a rule, rather irregular in the longitudinal direction, the valve being considerably flattened in the vicinity of the apex. The flattened portion of the valve unites with the remainder of the visceral part either in a regular spiral curve or in an obtusely rounded geniculation.

The apex is prominent, distinctly pointed and overhanging the hinge line, which corresponds to the greatest breadth of the shell.

The wings are rather large, spirally inrolled, and marked off from the lateral parts by a distinct furrow. The lateral parts are bent down towards the latter very steeply, in larger specimens nearly perpendicularly. If the wings are broken off, as is often the case, the general outlines of the shell appear to be almost square.

In all the specimens a median sinus is indicated, but it is rather variable in its depth and shape. If well developed, it recalls in shape the typical examples of *Productus gratiosus*. It always originates in the vicinity of the apex, and, as a rule, reaches its maximum strength near the point at which the valve appears most highly elevated above the hinge line. In most of the specimens it becomes more shallow in the frontal region, and often disappears completely near the front margin.

The trail is sometimes marked off from the remainder of the shell by a furrow or band, corresponding to the internal ridges along the margins of the opposite valve.

The ridges in the ventral valve, characteristic of the subgenus *Marginifera*, are accessible to observation when the wings have been broken off. They exhibit the peculiar crenulated appearance, which has been excellently described and figured by Waagen.

The sculpture consists of numerous, delicate, radial striæ, which originate in the apex and are nearly parallel for a considerable distance. Towards the front the radial sculpture becomes either quite indistinct, or is replaced by a few broader and more elevated ribs, especially so on the lateral portions of the valve. A distinct convergence of the radial striæ towards the median line of the sinus is rarely noticed. In this respect the sculpture of the majority of the Tibetan specimens resembles most closely that of Waagen's type from the cephalopod beds of Jabi (Pl. LXXVI, fig. 5). In the apical region a concentric sculpture is almost invariably indicated, but the concentric striæ are always but faintly marked and never equal in strength the radial sculpture.

The number of spines, which are scattered all over the surface of this valve, is very variable. They are however mostly distributed on the apical region and on the lateral parts along the furrow, which separates the wings from the remainder of the valve.

The dorsal valve (Pl. IV, fig. 12) is very deeply concave, leaving a comparatively small distance between itself and the opposite valve. Before reaching the ventral valve it suddenly flattens, presenting the appearance of a flat band, which passes around the anterior and lateral borders. This band, which is about 1 mm. in width, corresponds to the internal shelly ridges. The median fold is but very shallow. The shelly layer, which is but partially preserved, exhibits an indistinct reticulation in

the apical region and traces of a radial sculpture in its anterior portion. Small rounded grooves are disseminated irregularly on its surface. The wings are not accessible to observation.

The measurements of an average sized ventral valve with fairly preserved wings are as follows:—

Length of the shell in a straight line	23 mm.
" " " " along the curve	50 "
Breadth of the shell, with the wings	40 "
" " " " without the wings	26 "
Thickness of the ventral valve	17 "

The measurements of a complete specimen (Pl. IV, fig. 12), in which the two valves have been preserved, but without the wings, are as follows:—

Length of the shell in a straight line	20 mm.
" " " " along the curve	37 "
Breadth of the shell without the wings	26 "
Length of the dorsal valve	17 "
Thickness of the ventral valve	14 "
Distance of the two valves in the apical region	7 "

The shelly substance of both valves is very thin.

Number of specimens examined.—23.

Remarks.—*Marginifera typica* is one of the more common species of this subgenus in the Productus limestone of the Salt Range. It occurs chiefly in the middle and upper divisions of this formation, ranging there from the Katta beds to the Cephalopoda (Jabi) beds. It is, however, very rare in the Katta beds, whilst in the lower Productus limestone no characteristic specimens of the species have as yet been found.

Tschernyschew collected a good number of types of *M. typica* in the Artinskian horizon of the Ural Mountains and discovered a second very nearly allied species, *M. uralica* (p. 374, Pl. VI, fig. 16-18) in the upper carboniferous Fusulina limestone of the Ural. These two species are very similar and agree perfectly in their internal characters. The only points of difference between them are the presence of spines along the hinge line and the nearly smooth surface of the Russian shell in the vicinity of the lateral and frontal margins.

Some of Nikitin's specimens of *Productus longispinus* from the upper carboniferous strata of Central Russia bear a great resemblance to *M. typica*, especially the specimen figured on Pl. I, fig. 8, of his memoir. Nevertheless I dare not identify them with the present species, on account of the presence of numerous spines, both on the wings and along the hinge line, a character which is absent in *M. typica*, according to Waagen's description.

The differences between the Indian shell and its nearest allies, *M. pussilla*, Schellwien (Palæontographica, XXIX, p. 20, Pl. IV, fig. 18-21), *M. uralica* Tschernyschew, *M. splendens*, Norwood and Pratten (Jour. Ac. Nat. Sci. Philadelphia, III, 1855, p. 11, Pl. I, fig. 5), and *M. excavata*, Waagen (p. 715, Pl. LXXVIII, figs. 2, 3) have been fully discussed by Waagen, Tschernyschew and

Schellwien. I therefore need not dwell upon them, but may refer to the memoirs of these learned authors.

Notwithstanding the great resemblance between *M. typica* and *Productus longispinus*, Waagen believes a distinction of the two species to be possible, even if founded on external characters alone. In one respect, however, Waagen's statement needs a correction, when he denies the presence of *P. longispinus* in the Productus limestone of the Salt Range. Specimens identical with Sowerby's species and different from the true *M. typica* have been recognised by Schellwien among the fossils of the Schlagintweit collection from the Punjab.

With *Productus longispinus* and *P. semireticulatus* a specimen of *Marginifera* has been identified by Stoliczka, which is most nearly related to *M. typica*. The differences between the two consist chiefly in the strong reticulation and in the presence of a prominent median fold in the dorsal valve of the Himálayan form from Kashmir and Spiti. The casts of the dorsal valve were mistaken by Stoliczka for *Prod. semireticulatus*, whereas he identified the ventral valves with *P. longispinus*. A detailed description of this species for which I shall introduce the name of *Marginifera himalayensis*, will be given in a special memoir on the authracolitic rocks of Kashmir and Spiti (Pt. 2 of the present volume).

Genus: AULOSTEGES, Helmersen.

To this interesting genus belongs a new species from the permocarboniferous limestone of Chitichun No. I, which, while exhibiting the generic characters of *Aulosteges*, differs remarkably from any of the hitherto described congeneric forms. It consequently ought to be considered as type of a special group.

1. AULOSTEGES TIBETICUS, nov. sp. Pl. V, figs. 3-6.

This strange little shell is of a broadly triangular outline, with a semicircular front margin. Its ventral valve is moderately inflated, but rather variable in its convexity, which is very unequal in different directions. In its longitudinal direction it is but slightly curved in the apical region. Then follows a somewhat flattened part, which extends half way or more towards the front, when a blunt geniculation takes place, the remainder of the valve bending suddenly down to the front line. This geniculation is much more strongly marked, than in *Aulosteges medlicottianus*, Waagen (p. 663, Pl. LXII, fig. 1-4), and imparts to the present species a very peculiar and characteristic shape. Transversely the curve is more regular, being interrupted by a median sinus of variable depth and width. This median sinus originates in the immediate vicinity of the apex and reaches its greatest development near the line of geniculation of the ventral valve, whereas it is but faintly marked in the front margin.

The apex is always more or less deformed, prominent, and often incurved. It is not distinctly pointed. In some of my specimens it looks exactly, as if it had been fixed to a foreign body, whereas in others it does not show any mark of attachment.

above quoted figure, which I consider as typical, strongly recalls *A. tibeticus*. The geniculate character of the ventral valve and the strange sculpture are especially similar in the two shells. Specifically, however, the two forms are certainly distinct, even if *Strophalosia poyangensis* should turn out to be no true *Strophalosia* but a representative of the genus *Aulosteges*. The presence of distinct auricular expansions and the irregular character of the radial plications in the Chinese species make a distinction easy. Nevertheless they certainly ought to be united in the same group, if *Strophalosia poyangensis* should be found to belong to the genus *Aulosteges*.

Family: *LYTTONIIDÆ* (Waagen) Zittel.

In his monograph of the Productus limestone fossils, Waagen (1883) introduced the subfamily of *Lyttoniinae* for the reception of two very strange genera, *Oldhamina* and *Lyttonia*, the nearest allies of which he found among the family of *Thecideidæ*.

Of this subfamily he gave the following diagnosis: "Shell of large size, flat or vaulted, attached by the larger valve; hinge line straight and short, no area or pseudodeltidium; internally the ventral valve with a median and numerous lateral septa; dorsal valve rudimentary, forming together with the brachial apparatus one strongly lobed, shelly plate, which fits between the external septa of the large valve."

The *Lyttoniinae* have in common with *Thecidea* and *Pterophloios*, which have been united by Waagen in the subfamily of *Thecideinae*, the punctuate shell, the lobed brachial apparatus, and the attached larger valve. With regard to the persistence of these most striking characters Waagen proposed to leave these two subfamilies, together with the subfamily of *Megathyrinae*, in the family of *Thecideidæ*.

Ehlert (Fischer, Manuel de Conchyliologie, Brachiopodes, p. 1327) purified the family of the *Megathyrinae*, which are considered by him as a proper family, but again refers the *Lyttoniinae* to the family of *Thecideidæ*. K. von Zittel in his "Elements of Palæontology" (p. 235) elevated the *Lyttoniidæ* to the rank of a family. His view has been adopted in the present memoir.

Genus: *LYTTONIA*, Waagen.

1. *LYTTONIA NOBILIS*, Waagen. Pl. I, fig. 5, 6, 7.

1883. *Lyttonia nobilis* Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 398, Pl. XXIX, XXX, figs. 1, 2, 5, 6, 8, 10, 11.

Among the material from the permocarboniferous limestone of Chitichun No. I, there are several fragments of a large *Lyttonia*, which I believe to be identical with the present species from the Salt Range. No complete specimen has been met with, but the specimen figured Pl. I, fig. 5, is in a sufficiently good state of preservation, to exhibit most of the characteristic features, belonging to the shell of *Lyttonia*.

This specimen is of a broadly triangular outline, flatly spread out, and firmly attached by the underside of its ventral valve for its whole extent. Laterally it is strongly bent over, shelly expansions being occasionally noticed a little outside the proper margins. In the cardinal regions small fragments of the shelly substance have been preserved. The shell is about one half millimetre in thickness. I have not been able to examine its structure.

On the inner side of the ventral valve a median, longitudinal septum is distinctly developed, but is considerably surpassed in size by the lateral septa, which form high roof-shaped crests. The septa do not reach the lateral margins, but are rather suddenly obliterated a short distance from the latter. Thus a narrow, smooth rim is formed around the entire valve along its lateral margins. The septa are quite regularly developed and are placed symmetrically to the median, longitudinal septum. The last, rudimentary pair has been considered by Waagen as replacing the cardinal teeth. Excepting this cardinal pair of septa, twelve lateral septa have been noticed in my specimen (fig. 5) on each side of the middle line.

Of the dorsal valve a few fragments only have been preserved. Its shelly substance is very thin. Of its internal character the presence of a longitudinal median septum is the only one, which I have been able to observe.

Another specimen, figured Pl. I, fig. 6, exhibits the internal characters of the cardinal portion of a ventral valve. It is likewise remarkable for the regularity of the lateral septa, which are strongly curved upwards in the vicinity of the margins.

In fig. 7, the fragment of the ventral valve of a very large specimen has been represented. In this fragment the porous character of the shelly substance is very well exhibited. The pores are distinctly arranged in two zones along both sides of each lateral septum. These zones, which are distinguished by their punctuate or grooved sculpture, are equally well visible in Kayser's figure of *Lyttonia* (*Leptodus* Kayser), *Richthofeni* (Richthofen's "China" IV, Pl. XXI, fig. 10) from the upper carboniferous limestone of Lo-Ping.

Number of specimens examined.—5.

Remarks.—In my first report on the geology of the Chitichun crag (Denkschr. Kais. Akad. Wiss. Wien 1895, mat. nat. Cl., LXII, p. 589) I considered the present species to be rather nearly allied to *Lyttonia tenuis* Waagen (Pl. XXX, figs. 3, 4, 7, 9, p. 401). Waagen himself states *L. nobilis* and *L. tenuis* to be very similar species, which are not easy to distinguish, especially in fragments. It was only after a careful examination of my specimens, that I became convinced of their identity with *L. nobilis*. Their larger size, the massive development of the lateral septa in the ventral valve, and especially the greater thickness of the shelly substance, fragments of which I only detected after long painstaking, forbid an identification with *L. tenuis*.

The genus *Lyttonia* is a very peculiar southern type of the family *Lyttoniidae*. It is known from China, from Sicily,¹ from Kashmir, from the Salt Range, and

¹ G. Gemmellaro, Poll. Soc. Sci. Nat. ed Eoon, Palermo, 1891, No. I, 1892, No. III, 1894, No. 1.

from Chitichun No. I, but has not yet been found outside the subtropical portions Europe and Asia.¹ *Lyttonia nobilis* is common in the Virgal and Kalabagh beds of the middle Productus limestone of the Salt Range, but is absent in any other division of the Productus limestone.

Suborder : HELICOPEGMATA, Waagen.

Family : *SPIRIFERIDÆ*, King.

Subfamily : *SUESSIINÆ*, Waagen.

Genus : *SPIRIFERINA*, d'Orbigny.

Among the family of *Spiriferidæ*, which is one of the most natural families of this suborder, being easily recognised by very remarkable external and internal characters, Waagen has distinguished a number of subfamilies, all of which have their representatives in the permocarboniferous fauna of Chitichun No. I.

According to him, the first natural subfamily is formed by a group, of which the genus *Spiriferina* is the prototype. It is most nearly allied to Davidson's family of *Nucleospiridæ*, being provided with a transverse shelly band connecting the primary lamellæ, as in *Uncites*, and with a punctuate shell, as in *Retzia*. In this group, which were elevated to the rank of a subfamily, the *Suessiinæ*, by Waagen, *Spiriferina*, *Suessia* (which is, however, provided with a fibrous shell,) *Cyrtina* and, provisionally, *Mentzelia* were included. The latter genus must, however, be removed from the *Suessiinæ* and united with the *Martiniinæ* or *Reticulariinæ*, as has been proved by Bittner (Abhandl. K. K. Geol. Reichs-Anstalt, Wien, XIV, 1890, p. 25).

In the Chitichun fauna only the genus *Spiriferina* is represented, by *Sp. cristata*, Schloth., one of the most common and far spread species in carboniferous and permian strata.

1. *SPIRIFERINA CRISTATA* Schlotheim *var. OCTOPLICATA*, Sowerby. Pl. VII, fig. 5, 6, 7.

1816. *Terebratulites cristatus*, Schlotheim, Denkschr. K. Akad. Wiss., München, VI, p. 28, Pl. I, fig. 3.

1827. *Spirifer octoplicatus*, Sowerby, Min. Conch., p. 120, Pl. 562, tab. 2, 3, 4.

1837. *Spirifer cristatus*, L. von Buch, Ueber Spirifer oder Delthyris, und Orthis, p. 39.

1843. *Sp. cristatus*, L. de Koninck, Description des animaux fossiles, qui se trouvent dans le terrain carbonifère de Belgique, p. 240, Pl. XV, fig. 5.

1850. *Trigonotreta cristata*, King, Monograph of the permian fossils of England, p. 127, Pl. VIII, fig. 9-14.

1851. *Spirifer octoplicatus*, L. de Koninck, Supplément de la Description des animaux fossiles, qui se trouvent dans le terrain carbonifère de la Belgique, p. 658, Pl. XV, fig. 5.

1858. *Spiriferina cristata*, Davidson, Monograph British Permian Brachiopoda, p. 17, Pl. I, figs. 37-40, 45, 46, Pl. II, figs. 43-45.

1858. *Spiriferina cristata var. otuplicata*, Davidson, Monograph British Carboniferous Brachiopoda, p. 33, Pl. VII, figs. 37-47.

¹ This is not the case with *Oldhamina*, which has a true representative (*O. filicis* Keyserl.) in the carboniferous rocks of the Ural: A. de Keyserling, Note sur la présence de l' *Oldhamina* dans la Russie. Bull. Com. Géol. Russ., St. Pétersbourg, 1891, p. 257.

1861. *Spirifer cristatus*, Geinitz, *Dyas*, II, p. 88, Pl. XVI, fig. 8-10.
 1862. *Spiriferina octoplicata*, Davidson, *Quart. Journ. Geol. Soc.*, London, XVIII, p. 29, Pl. I, figs. 12, 13, 14, (*non* 11).
 1863. *Spiriferina octoplicata*, Davidson, in L. de Koninck, *Mémoire sur les fossiles paléozoïques. recueillis dans l'Inde*, p. 36, Pl. X, figs. 12, 13, 14 (*non* Pl. IX, fig. 11).
 1863. *Spiriferina cristata*, *Sp. octoplicata*, Davidson, *Monograph British Carboniferous Brachiopoda Appendix*, p. 267, Pl. LIV, figs. 10-13.
 1865. *Spirifer cristatus*, Beyrich, *Ueber eine Kohlenkalkfauna von Timor*, *Abhandl. K. Akad. Wiss. Berlin*, 1867, p. 79, Pl. I, fig. 4.
 1876. *Spirifer cristatus*, Trautschold, *Die Kalkbrüche von Miatschkowa*, p. 79, Pl. VIII, fig. 5.
 1877. *Spiriferina cristata*, White, in *Wheeler's Report upon the U. S. Geograph. Surveys west of the one hundredth Meridian*, Vol. IV, *Palæontology*, p. 139, Pl. X, fig. 8.
 1883. *Spiriferina cristata*, Waagen, *Pal. India*, ser. xiii, *Salt Range Fossils*, I, *Productus Limestone Fossils*, p. 499, Pl. XLIX, figs. 3-7.
 1884. *Spiriferina cristata*, Walcott, *Palæontology of the Eureka District*, *Mon. U. S. Geol. Survey*, VIII, p. 218, Pl. XVIII, figs. 12-13.
 1887. *Spiriferina octoplicata*, L. de Koninck, *Faune du calcaire carbonifère de la Belgique*, *Ann. Mus. Royal d'hist. nat. Belgique*, 6 ème ptie., p. 100, Pl. XXII, fig. 32-39.
 1889. *Spiriferina cristata*, Tschernyschew, *Allgemeine Geologische Karte von Russland*, Bl. 139, *Geologische Beschreibung des Central Urals und des Westabhangs*, *Mém. Com. Géol. Russ., St. Pétersbourg*, III, No. 4, p. 273.
 1890. *Spiriferina cristata*, Tschernyschew, *Travaux exécutés au Timane en 1889*, *Bull. Com. Géol. Russ.* p. 83.
 1892. *Spiriferina cristata*, Rothpletz, *Die Perm-Trias- und Juraformation auf Timor and Rotti*, *Palæontographica*, XXXIX, p. 81.

The identification of the Tibetan specimens with the present species can only be maintained, if the latter is accepted in the extension which has been adopted by Davidson and Waagen. They agree perfectly with Waagen's types from the *Productus* limestone of the Salt Range, but deviate slightly from the permian *Spiriferina cristata*, especially from Schlotheim's German Zechstein types.

All are of a comparatively large size, and of variable outlines. The greatest breadth of the shell is either situated at the hinge line, or as in the two specimens, figs. 5 and 6, a little towards the front. The area is of variable width and shape, more or less strongly reclining, and provided with a moderately large triangular fissure. As a rule, the lateral margins meet the hinge line in a sharp angle, at least in those specimens, in which the greatest breadth of the shell coincides with the hinge line. In some specimens, however (Pl. VII, fig. 6), the cardinal angles are almost rounded, not prolonged with acute terminations.

The ventral valve is as strongly inflated as the dorsal one, and is very regularly curved in both directions. The beak is small, pointed and strongly incurved. In the area of the specimen fig. 5, a distinct horizontal striation has been noticed.

The number of folds varies from eight to ten. The sinus is deep, more than twice as broad than the depressions between the adjoining folds, and extending from the extremity of the back to the front. In the two specimens, figs. 5 and 6, it is considerably produced beyond the frontal level of the lateral portions of the valve, whereas in other specimens (fig. 7) this is not the case. It is more or less sharply rounded in its bottom, and in one of the specimens (fig. 6) shows a well marked tendency to develop a rudimentary median fold. The crests of the folds are comparatively high and acutely rounded, exactly as in Waagen's figures.

The dorsal valve is provided with a linear area only. The number of its folds varies from nine to eleven. The median fold is always larger than those situated on the lateral portions. In specimens with a strongly protracted sinus this fold is elevated considerably above the general convexity of the valve. It is but slightly flattened on the top, especially so in the vicinity of the front margin, but never assumes the obscurely triplicated appearance, which has been observed by Davidson in some of his British types of *Spiriferina octoplicata*.

In the front of the two valves a few more or less strongly marked, imbricating striæ of growth are developed in the majority of my specimens.

The coarsely punctuate character of the shelly substance can easily be observed, even with the naked eye.

A concentric ornamentation, as in *Spiriferina insculpta* Phill., or in *Spiriferina kentuckensis* Shum., is completely absent.

The measurements of a specimen (fig. 6) with eleven folds on the dorsal valve are, as follows :—

Entire length of the shell	. . . . .	20	mm.
Length of the dorsal valve	. . . . .	15	„
Entire breadth of the shell	. . . . .	24	„
Length of the hinge line	. . . . .	22.5	„
Thickness of both valves	. . . . .	13.5	„
Apical angle of the ventral valve	. . . . .	108°	„
„ „ „ dorsal „	. . . . .	app. 125°	„

Number of specimens examined.—5.

Remarks.—Davidson was inclined to consider *Spiriferina cristata*, Schlotheim and *Sp. octoplicata*, Sow. as specifically identical, declaring, that “the latter form cannot claim to be considered more than a variety of *Sp. cristata*.” In this view the majority of palæontologists agree with Mr. Davidson, with the exception, however, of L. de Koninck and Schellwien, who think the differences between the two forms sufficient for a specific distinction.

L. de Koninck lays a special stress on the following characters of difference—the permian *Spiriferina cristata* is always smaller, the number of its folds is less, rudimentary ribs along the median fold of the dorsal valve are absent, the cardinal angles are rounded.

Both in the Tibetan and Salt Range types the number of folds is extremely variable (from 8 to 14 in the ventral, from 8 to 19 in the dorsal valve), but is never so small as in some specimens from the German Zechstein. The cardinal angles are either acute or indistinctly rounded. Secondary ribs, which occur at the sides of the median fold in the dorsal valve, have never been observed. In their dimensions they certainly exceed the typical form of Schlotheim's species, and approach more nearly the British types of *Spiriferina octoplicata*.

A more important difference between *Spiriferina cristata* and *Sp. octoplicata* than those, which were enumerated by L. de Koninck, has been signalized by Schellwien (Die Fauna des Karnischen Fusulinenkalks, Palæontographica, XXXIX, 1892, p. 50). He draws attention to the peculiar shape of the sinus in specimens from the German Zechstein, for which the name of *Sp. cristata* was first introduced

by Schlotheim, and which ought consequently to serve as prototypes of this species. In a very large number of specimens, which he was able to examine, he invariably found the bottom of the sinus forming an even plane and marked off by sharp borders from the adjoining lateral portions. Having myself no sufficient material at hand for comparison, I would hardly consider myself warranted in offering any decided opinion as to the specific claims of *Spiriferina cristata* and *Sp. octoplicata*. If their specific distinction should be found to be maintainable, the Tibetan specimens ought to be referred to *Sp. octoplicata*, not to Schlotheim's species.

Spiriferina cristata, in Davidson's definition of the species, is a form of very large geographical and geological distribution. It is not only common in the carboniferous and permian rocks of Western Europe, but has also been found in the Moscovian stage of Koroptschews in Central Russia, in the upper carboniferous and permocarboniferous rocks of the Ural and Timan Mountains, in the permian deposits of Timor, and in the Salt Range, where it reaches through the entire thickness of the Productus limestone series. All the Asiatic types of this species are more nearly allied to *Spiriferina octoplicata*, than to the true *Sp. cristata*.

To the present species, if taken in the wide extension of Davidson, Waagen, Beyrich and Rothpletz, some American shells have been correctly attributed by White and Walcott. I am not, however, inclined to accept all the synonyms in the list of the latter author, and must object to the identification of the shells in question with *Spiriferina spinosa*, Norw. and Pratt., from the Kaskaskia limestone, and with *Sp. kentuckensis* from the coalmeasures of the central and western parts of the United States. From the two last mentioned American species the Tibetan specimens differ in the absence of spines and of a regular concentric ornamentation.

From Höfer Island (Barents Islands, N.W. Novaya Semlya) *Spiriferina cristata* var. *octoplicata* has been mentioned by Toulou (Eine Kohlenkalk-Fauna von den Barents Inseln, Sitzungsber. K. Akad. Wiss. Wien, LXXI, 1875, p. 20), but the identification was based on incomplete casts only.

The shell from Spitzbergen, which has been described by L. de Koninck (Nouvelle notice sur les fossiles du Spitzberge, Ac. Roy. Belg., XVI) as *Sp. cristata*, can scarcely be united with Schlotheim's species, but deserves at least a varietal denomination.

Subfamily : DELTHYRINÆ, Waagen.

Genus : SPIRIFER, Sowerby.

L. von Buch divided the forms, which constitute the genus *Spirifer* proper, *i.e.* the radially plicated forms with a fibrous shell—his group of *Sp. alatus*—into two sections, the *Ostiolati* (type, *Spirifer ostiolatus*, Schloth.) with a smooth mesial sinus, and the *Aperturati* (type, *Sp. aperturatus*, Schloth.) with a plicated mesial sinus. The three species, by which this genus is represented in the permocarboniferous fauna of Chitichun No. I, belong exclusively to the section of

A perturati. Of these species two occur also in the Productus limestone of the Salt Range and in Europe; these are *Spirifer musakheylensis*, Dav., and *Sp. Wynnei*, Waag. The third species, *Sp. tibetanus*, nov. sp., is peculiar to the Chitichun fauna, but rather nearly related to *Sp. rajah*, Salter, from the upper carboniferous rocks of Kashmir and Spiti.

These species may be grouped most conveniently in the following manner:—

- I. GROUP OF SPIRIFER FASCIGER, Keyserl.
 - 1. *Sp. musakheylensis*, Davidson.
- II. GROUP OF SP. DUPLICICOSTA, Phill.
 - 2. *Sp. Wynnei*, Waagen.
- III. GROUP OF SPIRIFER RAJAH, Salter.
 - 3. *Sp. tibetanus* nov. sp.

Spirifer Wynnei and *Sp. tibetanus* are among the more common fossils of the material from Chitichun No. I, but *Sp. musakheylensis* is a very rare species.

I. GROUP OF SPIRIFER FASCIGER, Keyserl.

1. *Spirifer musakheylensis*, Davidson. Pl. VI, fig. 8.

1862. *Spirifer musakheylensis*, Davidson, Quart. Journ. Geol. Soc., London, XVIII, p. 28, Pl. II, fig. 2.

A complete list of synonyms has been given in my monograph of the permian fauna of the Productus shales (Pt. 4 of this volume).

Among the material from Chitichun No. I, there is only a single dorsal valve, which I refer to this species, one of the most common forms of the genus, both in the permian Productus shales of the Central Himalayas and in the upper carboniferous rocks of Kashmir and Spiti.

The present valve is transversely fusiform, with a hinge line, which is as long as the greatest breadth of the shell. The apex is a little more prominent, than is usually the case in specimens of a similar size, overhanging slightly the very narrow, almost linear area. The strongly elevated median fold is narrowly rounded on its top and is moderately curved in the longitudinal direction.

The fasciculation of the ribs is the most prominent feature in the ornamentation of this valve. Six or seven bundles of narrowly rounded ribs can be distinguished on each side of the median fold. Lamellose striæ of growth have not been noticed.

The measurements of this specimen are, as follows:—

Length of the dorsal valve	. . . . .	15 mm.
Breadth, „ „	. . . . .	35 „
Thickness „ „	. . . . .	6 „
Apical angle „ „	. . . . .	abt. 135° „

Number of specimens examined.—1.

Remarks.—The affinities of *Spirifer musakheylensis* to the congeneric species of the group of *Sp. fasciger*, Keys., have been fully discussed in my memoir on

the *Productus* shales fossils, to which I refer for further explanation. In this memoir I have explained the reasons, why, in my opinion, a special stress must be laid on the rounded shape of the folds in *Sp. musakheylensis*, but not on the presence of the lamellose striæ of growth, which are sometimes missing. Notwithstanding their absence, I deemed it preferable to identify the present specimen with Davidson's species, rather than *Sp. fasciger*, on account of the character of its lateral folds, which are very flat and wavy, but not acute, as in Grünewaldt's and Tschernyschew's type specimens of Keyserling's species.

The rarity of these shells, so common at other localities of the Himálayas, in the Chitichun crag, is a rather astonishing fact.

II. GROUP OF SPIRIFER DUPLICICOSTA, Phillips.

2. *Spirifer Wynnei*, Waagen. Pl. VII, figs. 1-4.

1883. *Spirifer Wynnei*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, *Productus* Limestone Fossils, p. 517, Pl. XLIV, figs. 6, 7.

1889. *Sp. Wynnei* (?), Tschernyschew, Mém. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 271, Pl. V, fig. 7, 8.

The differences between this species and the nearly allied *Spirifer duplicicosta* Phill. (Davidson, Mon. Brit. Carb. Brach., p. 24, Pl. III, figs. 7-10, Pl. IV, figs. 3, 5-11) from the mountain limestone of Western Europe have been clearly defined by Waagen. They consist chiefly in the very small development of the median fold and in the presence of a broader, more strongly reclining area in the dorsal valve of the median shell.

The specimens, from Chitichun No. I, agree entirely with Waagen's types from the Salt Range. The peculiar characters, so well displayed in the Punjab examples of *Sp. Wynnei*, can also be observed in the Tibetan shells. Owing to the larger number of specimens available for examination, the shape has been found more variable than was admitted by Waagen. Although the general outline is transversely oval in the majority of specimens, the length and width of the shell are equal in a small number. The hinge line is always shorter than the greatest breadth of the shell. The cardinal angles are distinctly rounded.

The ventral valve is always deeper than the opposite one. It is provided with a broad, concave, strongly reclining area and with a rounded mesial sinus, which is very shallow as a rule, but exceptionally is comparatively deep and narrow, as in the specimen fig. 2.

The radiating ribs are narrowly rounded at their tops, either single, or dichotomous, but never arranged in bundles. Their number is rather variable. Strong and erect, concentric lamellæ of growth have frequently been noticed.

In the dorsal valve of this species the most characteristic feature is the flatness of the median fold, which, as a rule, is barely marked off from the lateral parts. Waagen's specimen, Pl. XLIV, fig. 7, most nearly approaches the typical shape of the dorsal valve in the Tibetan specimens. Even in shells like the one

figured on Pl. VII, fig. 2, of this memoir, which are provided with a comparatively deep sinus, the mesial fold in the dorsal valve is very flat. Specimens, in which the mesial fold projects a little above the frontal wave of the ventral valve, as the one figured by Waagen on Pl. XLIV, fig. 6, are exceptional among the material from Chitichun No. I. The flatness of the median fold in the dorsal valve of *Sp. Wynnei* consequently appears to be a constant feature and may appropriately serve for a distinction between this species and *Sp. duplicicosta*.

The sculpture is exactly the same as in the larger valve.

The presence of strong dental plates in the ventral valve has been noticed. Otherwise I can say nothing of the internal characters of this species.

The measurements of my largest specimen (fig. 1) are, as follows :—

Entire length of the shell	. . . . .	40 mm.
Length of the dorsal valve	. . . . .	33 „
Entire breadth of the shell	. . . . .	51 „
Length of the hinge line	. . . . .	36 „
Thickness of both valves	. . . . .	23 „
Apical angle of ventral valve	. . . . .	108° „
„ „ „ dorsal valve	. . . . .	131° „

Number of specimens examined.—27.

Remarks.—In the Salt Range, *Spirifer Wynnei* is a very rare fossil, entirely restricted to the Virgal beds of the middle Productus limestone. A ventral valve, collected in the Artinskian deposits of Russia by Professor Tschernyschew, has been provisionally assigned to this species. Perrin Smith quotes *Sp. Wynnei*, from the argillites above the McCloud limestone in California, which he considers to be homotaxial with the topmost carboniferous limestones of the Ural Mountain and with the lower part of the Artinskian stage.¹

III. GROUP OF SPIRIFER RAJAH, Salter.

3. *Spirifer tibetanus*, nov. sp. . Pl. VI, fig. 1-7.

This characteristic and beautiful species recalls *Spirifer ovalis*, Phillips (Davidson, Mon. Brit. Carb. Brach., p. 53, Pl. IX, fig. 20-26) or *Sp. integricosta* Phill. (ibidem, p. 55, Pl. IX, fig. 13-19) in its general shape and outlines. It is longitudinally oval, or, especially in young specimens, nearly semicircular. The hinge line is always less than half the width of the shell, with rounded cardinal angles.

The ventral valve is considerably deeper than the opposite one. Its beak is prominent and strongly incurved. A mesial sinus of variable width and depth extends from the extremity of the beak to the front margin. It invariably reaches its maximum near the front, which is not produced beyond the lateral portions in any of the specimens. The area is of nearly equal height and width, and so narrow that the large triangular fissure occupies more than half of its entire surface.

¹ Perrin Smith, Mesozoic changes in the faunal geography of California; Journal of Geology, Chicago, III, 1895, p. 373.

The sculpture is both very elegant and prominent. The mesial sinus, in the centre of which there exists a narrow, thread-like rib, is bordered on each side by a large, broadly rounded rib. These two ribs become dichotomous in the apical region and are again subdivided into two smaller ones in the vicinity of the front. The lateral portions of the valve are ornamented with six to eight similar ribs on each side of these central ribs, which are, however, always the largest as well as the most prominent. Beyond the apical region all the lateral ribs are subdivided into two or three smaller ones of irregular strength and width. In the vicinity of the cardinal edges the lateral sculpture becomes gradually more indistinct.

The dorsal valve is less strongly convex than the ventral valve. It is provided with a very small, but distinctly developed area. The mesial fold is but slightly elevated above the regular convexity of the valve, but nevertheless sufficiently well defined from the lateral plications. It is composed of a single rib at its origin, and continues so to some distance, when it becomes dichotomous. In large specimens each of these two main ribs is again subdivided, before reaching the front. The intercostal depressions between the median fold and the lateral plications are ornamented with a smaller rib, which is either single or dichotomous, but always thin and far inferior in strength to the other ribs. The lateral folds, which occur to the number of seven or eight on each side of the median fold, are all broadly rounded, simple at their origin, and increase in height and width as they approach the margins of the valve. In young examples they continue as simple ribs to the very margin of the shell; in larger specimens, however, they become dichotomous or produce smaller ribs on each of their lateral portions.

In both valves the surface is almost invariably covered with numerous concentric lines of growth of irregular strength.

The internal characters of this species are not known to me.

The measurements, taken from an average sized example (fig. I), are as follows:—

Entire length of the shell	. . . . .	34 mm.
Length of the dorsal valve	. . . . .	28 "
Greatest breadth of the shell	. . . . .	33 "
Length of the hinge line	. . . . .	14 "
Thickness of both valves	. . . . .	21 "
Apical angle of the ventral valve	. . . . .	80°
" " " dorsal valve	. . . . .	118°

The species can attain very considerable dimensions, as specimens, measuring 60 mm. in length, have been noticed.

Number of specimens examined.—32.

Remarks.—The species, which is beyond doubt most nearly related to the present one, is *Spirifer rajah*, Salter (Palæontology of Niti in the Northern Himalayas, p. 59) from the upper carboniferous rocks of Kashmir and Spiti. According to the excellent description and figures, given by Davidson (Quart Journ. Geol. Soc., London, XXII, 1866, p. 40, Pl. II, fig. 3), the sculpture of *Sp. rajah* is of a very

similar type. The only important difference consists in the triplicate division of the main ribs in *Sp. rajah*, while they are, as a rule, dichotomous in *Sp. tibetanus*. This difference is most distinctly marked in the character of the median fold in the dorsal valve. In Salter's species this median fold is composed of a prominent median rib, which produces smaller ones on each of its lateral portions, but continues as main rib to the front. In *Sp. tibetanus* the original median rib is not continued to the front but becomes subdivided in two ribs of equal width and strength. With regard to their general shape and outlines the two species stand in a similar relationship, as *Sp. ovalis*, Phill. to *Sp. pinguis*, Sow. *Spirifer tibetanus* is easily distinguished from *Sp. rajah* by the shortness of its hinge line and area, the last being much more triangular and higher in proportion to its width.

Spirifer Keilhavii, von Buch (Ueber *Spirifer Keilhavii*, über dessen Fundort und Verhältniss zu ähnlichen Formen, Abhandl. K. Akad. Wiss. Berlin, 1876, p. 65), which is nearly allied to *Sp. rajah*, differs from the present species in the same characters, by which it is distinguished from the former, and by the absence of a median rib in the sinus of the ventral valve.

Another species, which must be compared with *Spirifer tibetanus*, is *Sp. parryanus*, Toula (Permocarbon Fossilien von der Westküste von Spitzbergen, Neues Jahrbuch, 1875, p. 256, Pl. VII, fig. 8) from Spitzbergen (Hinlopen Straits). Both from Toula's figures and description and from a personal examination of his type specimens, I have been convinced of the close relationship existing between these two species. *Sp. parryanus* approaches more nearly the *Sp. rajah* by its comparatively longer hinge line and area, but agrees with the present species in the dichotomous character of the median fold of the dorsal valve. The ornamentation is of the same pattern, as in *Sp. tibetanus* and in *Sp. rajah*, being composed of broadly rounded ribs, which become subdivided in the vicinity of the front. The development of a well defined median rib in the sinus of the ventral valve is also an important character, which is common to these three species.

Among the representatives of this group of the genus *Spirifer*, characterised by large, broadly rounded, subdivided radial ribs, *Spirifer Wilczeki*, Toula, *Sp. tasmaniensis*, Morris, and *Sp. interplicatus*, Rothpletz, may be mentioned. Their relationship to our species is, however, only a rather distant one, and will be more fully discussed in the description of *Sp. rajah* in the second part of the present volume.

This group seems to be entirely absent from the Productus limestone of the Salt Range.

Subfamily : *MARTINIINÆ*, Waagen.

Genus : *MARTINIA*, M'Coy.

The name *Martinia* has been proposed by M'Coy as a generic denomination for such forms, as belong to the relationship of *Anomites glaber*, Martin. Davidson and L. de Koninck, however, rejected it and classed these forms in the genus

Spirifer, proving M'Coy's diagnosis of his new genus to be insufficient and in part even erroneous. Generic rank was restored to *Martinia* by Waagen, who was the first to draw attention to some characters of its typical species, deserving of a distinct generic designation. Such characters are the existence of a punctured surface of the epidermis, and the absence of septa in the ventral valve.

Martinia, if Waagen's definition of this genus is adopted, is rather richly represented in the permocarboniferous fauna of Chitichun No. I, both in number of species and individuals. But most of the specimens are too incomplete to allow a satisfactory determination. Nevertheless six species at least can be distinguished.

The typical *Martinia glabra* Mart., which in Europe is the most common and widely spread type of this genus in carboniferous and permocarboniferous deposits, is barely represented. I can only attribute a single specimen to *M. glabra*, and even this does not approach the typical shape of that form, but is distinguished by the absence of a distinct sinus in the ventral valve.

All the rest of the specimens differ from *M. glabra* by a considerably shorter hinge line, terminating occasionally on both sides in little wing-shaped prominences, and by a smaller area.

Among the species, which I am able to distinguish, *Martinia nucula*, Rothpletz, *M. semiplana*, Waagen, and *M. contracta*, Meek and Worthen, are identical with previously described species. The two remaining species are new ones and will receive the names of *M. acutomarginalis* and *M. elegans*. The first is nearly allied to *M. carinthiaca*, Schellwien, from the Carnian Fusulina limestone of upper carboniferous age. The second one seems to bear a close relationship both to *M. nucula*, Rothpl. and to *M. Warthi*, Waagen.

Waagen arranged the Salt Range species of the genus *Martinia* in three different groups. I did not think it advisable to follow his example, as these groups are based on external characters only. As has been proved by Tschernyschew's remarks regarding the internal characters of *Martinia semiplana* (?) and *M. corcutum* (Mém. Com. Géol. Russ., St. Pétersbourg, 1889, III, p. 369), very different types may easily be united in one single group, if their internal structure is not accessible to observation.

The rich development of the genus *Martinia* in the fauna of the Chitichun limestone contrasts sharply with its rarity in the fauna of the Salt Range Productus limestone. In the latter the few species, which have been described by Waagen, "occur in rather sporadic and isolated specimens, thus clearly indicating, that they are either stragglers from a territory, where the genus is far more plentifully developed, or that they are the last representatives of a group of forms, which is on the verge of becoming extinct, and which had been more copiously developed in a former period." The number of specimens examined, as quoted in the diagnosis of each species described in this memoir, does not give an adequate idea of the actual number of representatives of this genus in the Tibetan collection. But among 76 specimens of *Martinia*, 19 only were found to be sufficiently well preserved to allow a specific determination.

1. MARTINIA CF. GLABRA, Martin. Pl. IX, fig. 4.

1809. *Conchylolithes Anomites glaber*, Martin, *Petrificata Derbyensa*, p. 11.

For further synonyms see Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 531, and my memoir on the fauna of the Himálayan Productus shales (Pt. IV of the present volume).

The only specimen available for description resembles in its circular outline, and in the absence of a well defined sinus, the example from Yorkshire figured by Davidson on Pl. XII, fig. 10, of his monograph of the British carboniferous brachiopoda, and only referred to *M. glabra* with considerable hesitation. The present specimen, however, differs considerably from the British fossil in the remarkably small disproportion in the depth of the two valves.

The ventral valve is moderately vaulted and of almost equal length and breadth. The beak is but slightly prominent beyond the hinge line, incurved, and of moderate dimensions. The hinge line is considerably longer, than in all the rest of congeneric species, occurring in the permocarboniferous limestone of Chitichun No. I. It is more than one half the entire breadth of the shell. The area is comparatively large, elongated, and marked off from the remainder of the shell by sharply defined lateral margins. A sinus is but very indistinctly indicated in the vicinity of the frontal region. Nevertheless the frontal line is strongly produced, forming a tongue-shaped wave, which causes the front margin of the dorsal valve to be elevated above its general convexity.

The dorsal valve is but partly preserved. It is very regularly curved in both directions, but slightly flattened in the proximity of the hinge line, where the latter unites with the lateral margins. A median fold seems to have been present in the frontal region only.

The ornamentation of the shell is of the same pattern as in the majority of specimens of the common *M. glabra*.

The measurements of this specimen are, as follows:—

Entire length of the shell	. . . . .	28	mm.
Length of the dorsal valve	. . . . .	23	„
Entire breadth of the shell	. . . . .	25	„
Length of the hinge line	. . . . .	13.5	„
Thickness of both valves	. . . . .	17.5	„
Apical angle of the ventral valve	. . . . .	app.	90°
„ „ „ „ dorsal „	. . . . .		108°

Number of specimens examined.—1.

Remarks.—Waagen (p. 537) considers the shells, figured by Davidson on Pl. XII, figs. 9 and 10, of his monograph, and referred with hesitation only to *M. glabra*, as very near allies to the Russian *M. corculum*, Kutorga (*Verhandl. K. Russ. Mineralog. Ges.*, St. Pétersbourg, 1872, p. 25, Pl. V, fig. 9.) As regards its external shape the present specimen may likewise hold an intermediate position between the true *M. glabra* and *M. corculum*. I do not, however, think, that it should be identified with the latter species, which is characterised by a very unequal depth of its two valves.

In their internal characters a remarkable difference between *M. glabra* and *M. corculum* has been noticed by Tschernyschew (Mém. Com. Géol. Russ., St. Pétersbourg, 1889, III, No. 4, p. 369), who observed the existence of a large median septum in the ventral valve of Kutorga's type specimens, whereas in *M. glabra* both septa and dental plates are absent.

In my specimen the internal characters are unfortunately not accessible to observation. Externally, however, it seems to be much more nearly allied to Martin's species than to the Russian form. I consequently deemed it preferable to leave it with *M. glabra*, without venturing, however, to identify it with the typical form of this latter species.

Although *M. glabra* is most abundant in carboniferous rocks, specimens, which only differ from the typical form by a shorter hinge line, are found in permian strata (Productus shales of Kiunglung encamping ground, Painkhánda). No geological importance can therefore be attributed to the presence of the specimen under consideration in the permocarboniferous limestone of Chitichun No. I.

2. MARTINIA NUCULA, Rothpletz. Pl. VIII, figs. 5, 6.

1892. *Martinia nucula*, Rothpletz, Die Perm- Trias- und Juraformation auf Timor und Rotti, Palæontographica, XXXIX, p. 80, Pl. IX, fig. 3, 7.

This species, which is not at all rare in the permocarboniferous limestone of Chitichun No. I, is distinguished from the true *Martinia glabra* Mart., according to Rothpletz, by the strongly inflated apical region, by its very short hinge line, and by its small, indistinctly defined area.

In young specimens the sinus is only indicated by a median depression in the frontal part of the ventral valve. In larger specimens it is, however, more strongly developed as a rule. Its continuation towards the apical region is sometimes marked by a narrow, longitudinal impression or furrow. The front line ascends in a highly elevated tongue-shaped curve. In young specimens this frontal wave is almost acutely rounded, as in the figure given by Rothpletz on Pl. IX, fig. 7, of his memoir, but in later stages of growth it forms a more regular curve.

Rothpletz states that the apices of the two valves touch each other in full grown individuals. None of my specimens exhibit this character, although in some of them the two apices are rather approximate. But even my largest example does not attain the dimensions of the type specimen from Timor (loc. cit. Pl. IX, fig. 3), and, moreover, the shell is but partially preserved in its apical region (cf. Pl. VIII, fig. 5). When the beak is perfectly preserved, as is the case in the smaller specimen, fig. 6, it appears to be strongly incurved and pointed.

In spite of the strong inflation of the apical region in the ventral valve, the two valves do not differ in depth very conspicuously. This is a good character of distinction from *M. semiplana*, Waagen, in which the dorsal valve is but slightly vaulted.

In the shape of the very small and obscurely defined area *M. nucula* agrees with *M. contracta*, Meek and Worthen (Palæontology of Illinois, p. 298, Pl. 23, fig. 5), as

has been remarked by Rothpletz. To the differences of these two species, enumerated by that author, the shape of the beak may be added, which is very prominent in the Asiatic fossil, but barely projects beyond the hinge line in the American species.

The surface of the shell is smooth and covered with very numerous puncta, where its epidermis has been preserved. In the specimen, figured on Pl. VIII, fig. 5, a number of indistinct, rounded ribs may be observed near the lateral margins of the dorsal valve.

Rothpletz noticed the presence of two dental plates in the ventral valve of his species, a character, which is absent in the typical *Martinia glabra*. I have not succeeded in making out anything of the internal structure of my specimens.

The measurements of the largest specimen (Pl. VIII, fig. 5) are, as follows:—

Entire length of the shell	. . . . .	35 mm.
Length of the dorsal valve	. . . . .	28 „
Entire breadth of the shell	. . . . .	38.5 „
Length of the hinge line	. . . . .	9 „
Thickness of both valves	. . . . .	24 „
Apical angle of the ventral valve	. . . . .	90°
„ „ „ „ dorsal	„	app. 110°

Number of specimens examined.—5.

Remarks.—Rothpletz believes his species to be identical with the Artinskian form, which has been identified with Waagen's *M. semiplana*, by Tschernyschew (Mém. Com. Géol. Russ., St. Pétersbourg, 1889, III, No. 4, p. 369, Pl. V, figs. 1, 3). I am not inclined to follow this view, in which no sufficient strength has been laid on the fact, that the Artinskian species is provided internally with a large median septum, whereas two dental plates are present in the ventral valve of *M. nucula*.

From the Indian *Martinia semiplana*, Waagen (Pal. Indica, ser. xiii, I, p. 586, Pl. XLIII, fig. 4) the present species differs considerably by its larger size, by the absence of ridges bordering the area, and by the nearly equal depth of the two valves.

Martinia nucula has been collected by Wichmann in the permian rocks of the island of Timor.

3. MARTINIA CONTRACTA, Meek and Worthen. Pl. IX, fig. 3.

1866. *Spirifer glaber* (Mart.) var. *contractus*, Meek and Worthen, Geological Survey of Illinois, Vol. III, Palæontology, p. 298, Pl. 23, fig. 5.

The specimens from the permocarboniferous limestone of Chitichun No. I, which ought, in my opinion, to be identified with the present species, agree in every respect with the description and figures as given by Meek and Worthen in the memoir quoted above.

Although in my monograph of the Productus Shales Fossils (Pt. iv of this volume) I have quoted *Martinia contracta* as a mere variety of *M. glabra*, Mart. sp., I now perfectly agree with Rothpletz (Palæontographica, XXXIX, p. 80) in considering it to be a true species. It belongs to the same group of forms as *M. semiplana*, Waagen, its two valves being of very unequal depth.

It differs from *M. glabra* "in having a much smaller and more obscurely defined ventral area. Indeed the sides of the beak of its ventral valve round in so regularly to the foramen, that it is often difficult to see where the margin of the area is." (Meek and Worthen, *loc. cit.*, p. 299.)

From *M. semiplana* the present species is easily distinguished by its larger size, by the absence of any ridges, bordering the small, triangular area, and by the presence of a shallow sinus in the ventral valve in the proximity of the front.

The differences between *M. contracta* and *M. nucula* have been enumerated by Rothpletz. They chiefly consist in the strongly inflated apical region of the ventral valve in the latter species, and in the different shape of the frontal wave which is sharply rounded or tongue-shaped in *M. nucula*, whereas it forms a shallow curve only in *M. contracta*. Nor does the small, well incurved beak project beyond the hinge line in the present species.

No median fold or crest is developed in the dorsal valve.

The figured specimen is of nearly the same size as the American one, figured by Meek and Worthen. Its measurements are, as follows:—

Entire length of the shell	. . . . .	22	mm.
Length of the dorsal valve	. . . . .	17.5	„
Entire breadth of the shell	. . . . .	22.5	„
Length of the hinge line	. . . . .	app. 10	„
Thickness of both valves	. . . . .	14.5	„
Apical angle of the ventral valve	. . . . .	82°	
„ „ „ „ dorsal „	. . . . .	app. 110°	

The ornamentation of the nearly smooth shell is of the same pattern, as in *M. glabra*. The puncta are of the epidermis have been observed in a few places of the ventral valve.

Number of specimens examined.—3.

Remarks.—*M. contracta* has been collected in the Chester group of the lower carboniferous series in Illinois.

4. MARTINIA SEMIPLANA, Waagen. Pl. VIII, fig. 7.

1883. *Martinia semiplana*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 536, Pl. XLIII, fig. 4.
 1889. *Martinia*(?) *semiplana*?, Tschernyschew, Geologische Beschreibung des Central Urals und des Westabhanges, Mém. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 369, Pl. V, fig. 1, 3.
 1892. *Martinia semiplana*, Schellwien, Die Fauna des Karnischen Fusulinenkalks, I. Th., Palæontographica, XXXIX, p. 39, Pl. IV, fig. 12-15.

This species belongs to a group of forms, which are characterised by the unequal depth of the two valves, of which the dorsal valve is considerably flatter.

The ventral valve is of a circular outline, strongly vaulted, and provided with a broad beak, which projects considerably beyond the hinge line. The small and concave area is pierced by a comparatively large triangular fissure and marked off from the remainder of the shell by distinct, though very low, ridges. In the specimens under description a sinus is entirely absent, but replaced by a thread-like mesial furrow. The frontal part is but slightly produced and ascends in a very flat curve.

The dorsal valve is much flatter than the opposite one, and more strongly curved in the transverse than in the longitudinal direction, whereas in the ventral valve the curve is almost equally strong in both directions. No median fold corresponds to the longitudinal impression in the ventral valve, but the median part of the dorsal valve is shaped into a sort of an obtusely rounded crest, from which on both sides the valve flatly slopes down in a roof-like manner.

Martinia semiplana is a rather small species. The measurements of the figured specimen are as follows:—

Entire length of the shell	. . . . .	14 mm.
Length of the dorsal valve	. . . . .	12 „
Entire breadth of the shell	. . . . .	14 „
Length of the hinge line	. . . . .	5 „
Thickness of both valves	. . . . .	8 „
Apical angle of the ventral valve	. . . . .	85°
„ „ „ „ dorsal	„	118°

Number of specimens examined.—2.

Remarks.—*Martinia semiplana* has been quoted by Waagen from the Virgal beds of the middle Productus limestone in the Salt Range, and by Schellwien from the Carnian Fusulina limestone of the Krone, which corresponds in its stratigraphical position to the Gshelian stage of Central Russia and to the upper carboniferous Fusulina limestone of the Ural Mts.

Tschernyschew identified an Artinskian *Martinia* with Waagen's Salt Range species, but grave doubts have been raised as to the correctness of this identification. Tschernyschew gives the following description of the internal characters in his Artinskian form:

The internal structure of this species “differs considerably from that in a typical *Martinia*, which is distinguished by the absence of any septa or dental plates in its ventral valve. A median septum distinctly shows through the transparent shells of the Artinskian specimens, from the apex of the ventral valve for the third part of the length of the latter. A septum of exactly the same shape is visible in the ventral valves of *M. corculum*, as I have been able to state from my personal examination of Kutorga's type specimens. In this respect the upper carboniferous and Artinskian species recall the triassic genus *Mentzelia*, Quenstedt, from which they differ, however, in the absence of dental plates. I think that these forms might rightly serve as prototypes of a distinct genus, although I prefer to abstain from giving a name to the latter, in view of our insufficient knowledge of its internal characters.”

Waagen has observed nothing of the internal characters of his type specimen from the Salt Range. But Schellwien, who examined some of his Carnian examples, did not succeed in finding any trace of a median septum in their ventral valves. That the specimens from the Fusulina limestone of Carinthia are identical with the Indian *M. semiplana*, cannot be questioned, as his identification has been confirmed by Waagen himself on the ground of his personal examination of Schellwien's types. It is therefore very doubtful, if the Artinskian shell, described by Tschernyschew, ought to be united with the present species.

Rothpletz (*Palæontographica*, XXXIX, p. 81) likewise believes Tschernyschew's Artinskian species to be different from *Martinia semiplana*, but identifies it, although with some hesitation, with his *M. nucula* from Timor. I think this should not be done, because in *M. nucula* the ventral valve is internally provided with two dental plates, but not with a median septum.

5. MARTINIA ELEGANS, nov. sp. . Pl. VIII, figs. 1, 2; Pl. IX, figs. 1, 2.

The specimens, for which this new denomination is introduced, recall the group of *Martinia Warthi*, Waagen (*Pal. Indica*, ser. xiii, I, p. 530) by the development of little wings on both sides of the very short hinge line.

M. elegans is a large and beautiful species. Its general outline is either slightly elongated or as long as it is broad. The valves are not equally inflated, the dorsal valve being, as a rule, less deep than the ventral one, but the disproportion in their depth is not very considerable. It is more conspicuous in the type figured on Pl. IX, fig. 1, than in all the rest of my specimens.

The ventral valve is strongly vaulted and about equally curved in both directions. The apical region is not so much inflated as in *M. nucula*. The beak is rather small, well incurved, and scarcely projects beyond the hinge line. It bears on its dorsal side a very small, concave area of a nearly equilateral shape, which is almost entirely occupied by the triangular fissure. This area is separated from the remainder of the shell by sharp and narrow, often considerably elevated ridges. In some of the specimens these ridges are bordered by a flatly rounded furrow along their exterior margins.

The hinge line is very short, reaching one third, or, exceptionally, two fifths of the entire breadth of the shell only, and terminates on both sides in little wing-shaped prominences.

A mesial sinus is always distinctly indicated, originating either in the apical region or reaching up at least half way from the line. It causes the frontal part of the shell to ascend rather strongly into a frontal wave. The latter is much more strongly elevated in full grown than in adolescent individuals. In the largest specimen (Pl. VIII, fig. 1) it is distinctly tongue-shaped and produced into a sort of a ridge, which overhangs the general convexity of the dorsal valve. This character is chiefly observable in a lateral view of the shell (fig. 1. c).

In the dorsal valve there is no median fold or crest, corresponding to this sinus. It is much more strongly vaulted in the transverse than in the longitudinal direction. Longitudinally it is distinctly curved in the apical region only, but flattened or even slightly hollowed in the vicinity of the front line. The apex is little prominent and slightly bent over. The narrow concave area is bordered by similar ridges, like in the ventral valve.

In one of the specimens (Pl. VIII, fig. 2) the surface of the shell is sufficiently well preserved to show the punctation. As in a typical *Martinia* it consists of very numerous irregularly clustered granulations and impressions, giving to the epidermis of the shell the appearance of shagreen. Besides this very faint

ornamentation, both valves are covered with numerous thin, concentric lines of growth. Traces of a radial sculpture are occasionally indicated in the proximity of the lateral margins.

Of the internal characters of this species nothing is known to me.

The measurements of the largest specimen are as follows:—

Entire length of the shell	51 mm.
Length of the dorsal valve	44.5 "
Entire breadth of the shell	47 "
Length of the hinge line	19 "
Thickness of both valves	32 "
Apical angle of the ventral valve	84°
" " " " dorsal "	103°

Number of specimens examined.—6.

Remarks.—This species can be easily distinguished from all the congeneric forms which have been hitherto described.

From *Martinia nucula*, Rothpletz, which it resembles in external shape, especially in the development of the sinus and of the tongue-shaped frontal wave, it differs in its less strongly inflated apical region, its sharply limited area, and the development of little wings on both sides of the hinge line. Nor are the beaks of the two valves ever so conspicuously approximate.

From *M. semiplana*, Waagen, it is distinguished by its much larger size, by the lesser disproportion in the depth of the two valves, by the presence of a well developed median sinus, and by its hinge line terminating in little wings.

The differences between our species and all the Salt Range forms belonging to the group of *M. Warthi*, Waag., are so conspicuous that I need not dwell upon them.

6. MARTINIA ACUTOMARGINALIS, nov. sp. . Pl. VIII, figs. 3, 4.

This is a small species, with a slightly elongate and pentagonal outline.

The ventral valve is strongly but very regularly vaulted. The apical region is barely less inflated than in *Martinia nucula*, Rothpletz. The beak is thick, little prominent beyond the hinge line, and well incurved. The area is small, indistinctly defined, and occupied almost entirely by the equilateral triangular fissure. The hinge line is very short, with rounded terminations, and without any wing-shaped prominences. The sinus is very broad, perfectly flat, and entirely restricted to the strongly produced frontal part. It is limited on both sides by a short, rounded fold, which is followed again by a rounded depression or furrow. This sort of sculpture gives to the lateral margins of the valve a zigzag shape. In the frontal region the middle part of the shell, corresponding to the sinus, is much produced, and causes the frontal wave to ascend very strongly.

The dorsal valve is also strongly vaulted, especially so in the apical region, whereas it gradually flattens in the longitudinal direction, when approaching the front line. The beak is slightly bent over, and overhangs an extremely narrow, indistinct area. The apices of the two valves are rather approximate.

In the frontal portion a broad, indistinct median fold corresponds to the sinus in the opposite valve. It is limited on both sides by rounded depressions which are followed again by very low and short folds. This sort of sculpture is entirely restricted to the proximity of the lateral and front margins, which are slightly elevated and shaped into sharp edges.

The ornamentation consists of very thin and numerous concentric striæ of growth. In the depressions on both sides of the median fold of the dorsal valve, thin radial striæ have been noticed.

The measurements of the smaller, but more complete, specimen (Pl. VIII, fig. 3) are as follows:—

Entire length of the shell	. . . . .	13	mm.
Length of the dorsal valve	. . . . .	10	"
Entire breadth of the shell	. . . . .	11.5	"
Length of the hinge line	. . . . .	4.5	"
Thickness of both valves	. . . . .	10	"
Apical angle of the ventral valve	. . . . .	75°	
" " " " dorsal "	. . . . .	110°	

Number of specimens examined.—2.

Remarks.—This species seems to be very nearly related to *M. carinthiaca*, Schellwien (Palæontographica, XXXIX, 1892, p. 41, Pl. VIII, fig. 15, 16) from the upper carboniferous beds of the Krone in the Carnian Alps. It is only distinguished from the latter by very subordinate characters,—namely, by its thicker, more strongly incurved beak of the ventral valve, and by the trapezoidal shape of the frontal wave. In this respect *M. acutomarginalis* is very similar to *M. Warthi*, Waagen (p. 533, Pl. XLIII, figs. 2, 8), from which species it differs, however, in the absence of any ridges or furrows separating the area from the remainder of the ventral valve, and in the rounded, wingless terminations of its hinge line. In spite of the external similarity to *M. Warthi*, the present species therefore seems to be more nearly allied to *M. carinthiaca*. Their relationship is certainly a very close one.

Subfamily: RETICULARIINÆ, Waagen.

Genus: RETICULARIA, M'Coy.

This genus, which was introduced by M'Coy for *Reticularia reticulata* and its allies, is represented in the permocarboniferous fauna of Chitichun No. I by one single species only, *R. lineata*, one of the most common and far-spread forms in the carboniferous and permian rocks of the Old World.

1. RETICULARIA LINEATA, Martin. Pl. IX, figs. 5, 6, 7, 8.

1809. *Conchylolithus Anomites lineatus*, Martin, Petrificata Derbyensia, Pl. XXXVI, fig. 3.

1821. *Terebratula lineata*, Sowerby, Mineral Conchology, Vol. IV, p. 39, Pl. CCCXXXIV, figs. 1, 2.

1836. *Spirifera lineata*, Phillips, Geology of Yorkshire, p. 219, Pl. X, fig. 17.

1840. *Spirifera lineata*, v. Buch, Essai d'une classification des Delthyris, Mém. Soc. Géol. France, IV, p. 199, Pl. X, fig. 25.

1843. *Spirifer lineatus*, L. de Koninck, Description des animaux fossiles, qui se trouvent dans le terrain carbonifère de Belgique, p. 270, Pl. XVII, fig. 8.
1844. *Reticularia lineata*, M'Coy, Synopsis of the characters of the carboniferous fossils of Ireland, p. 143.
1845. *Spirifer lineatus*, de Verneuil, Géologie de la Russie d'Europe, etc., Vol. II, Paléontologie, p. 147, Pl. VI, fig. 6.
- 1857—1862. *Spirifera lineata*, Davidson, Monograph of the British Carboniferous Brachiopoda, p. 63, Pl. XIII, figs. 4—10.
1865. *Spirifer lineatus*, Beyrich, Ueber eine Kohlenkalkfauna von Timor, Abhandl. K. Akad. Wiss. Berlin, p. 76, Pl. I, fig. 13.
1873. *Spirifer lineatus*, L. de Koninck, Monographie des fossiles carbonifères de Bleiberg en Carinthie, p. 55, Pl. II, fig. 11.
1876. *Spirifer lineatus*, Trautschold, Die Kalkbrüche von Mjatschkowa, p. 79, Pl. VIII, fig. 7.
1878. *Spirifer lineatus*, Abich, Geologische Forschungen in den kaukasischen Ländern I. Th. Eine Bergkalk Fauna aus der Araxenge bei Djoulfa, p. 79, Pl. VI, fig. 6, 7, 8; Pl. VII, fig. 10; Pl. IX, fig. 5.
1883. *Reticularia lineata*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 540, Pl. XLII, figs. 6—8.
1883. *Spirifer lineatus*, Kayser, Obercarbonische Fauna von Loping, Riechthofen's China, IV, Bd., p. 174, Pl. XXII, figs. 6-7.
1889. *Reticularia lineata*, Tschernyschew, Mém. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 368.
1890. *R. lineata*, Nikitin, Mém. Com. Géol. Russ., St. Pétersbourg, V, No. 5, p. 66.
1892. *R. lineata*, Schellwien, Die Fauna des Karnischen Fusulinenkalks, I Th., Palæontographica, XXXIX, p. 38, Pl. VI, fig. 10—13.
1892. *R. lineata*, Rothpletz, Die Perm.-Trias- und Juraformation auf Timor und Rotti, Palæontographica, XXXIX, p. 81 Pl. IX, fig. 8.
1894. *R. lineata*, Suess, Beiträge zur Stratigraphie Central Asiens, Denksohr. K. Akad. Wiss. Wien, math. nat. Cl., LXI, p. 453.
1895. *R. lineata*, Tornquist, Das fossilführens des Untercarbon am östlichen Rossbergmassiv in den Südvogesen, Abhandl. zur Geologischen Specialkarte von Elsass Lothringen, V, pt. 4, p. 121, Pl. XVI, fig. 6.
1896. *Martinia lineata*, Julien, Le terrain carbonifère marin de la France Centrale, p. 98, Pl. II, fig. 9—13, Pl. VIII, fig. 6.

Among the collections from Chitichun No. I, this species is rather richly represented by specimens of very different size, but varying little in their general shape and outlines. The majority come very near the typical form from the English mountain limestone, especially the type from the Craven district, figured by Davidson on Pl. XIII, fig. 8, of his monograph.

My specimens are suborbicular or elongately oval, although the difference in length and breadth is somewhat small. They are strongly inflated, the two valves being, as a rule, almost equally deep. The hinge line is always considerably shorter than the greatest breadth of the shell, and provided with rounded cardinal angles.

In all my specimens the ventral valve is distinguished by a high and strongly incurved beak. In this respect they recall the variety of *R. lineata*, from the permian rocks of Timor, which has been figured by Beyrich. In the Tibetan specimens, however, the beak never projects so strongly as in Beyrich's figure (Pl. I, fig. 13*b*), but the apices of the two valves are always rather distant, like in the specimen, fig. 10, on Pl. XIII, of Davidson's monograph. In well preserved examples the beak is distinctly pointed. The area is small and only obscurely defined by lateral margins. The triangular fissure, in which traces of a pseudo-deltidium have been occasionally noticed, is of the same shape and size as in Davidson's British examples.

In the majority of the specimens the sinus is very shallow and confined to the proximity of the front. In young individuals (Pl. IX, fig. 7) it is barely indicated at all. The only specimen among the materials from Chitichun No. I, provided with a deeper sinus, is the one figured on Pl. IX, fig. 6. In this specimen the frontal part of the shell is slightly produced and elevated.

The dorsal valve is very evenly convex and without any median elevation. The shape of the apical region and of the area agree with the description given of these characters in the Salt Range specimens by Prof. Waagen.

The sculpture is exactly the same as in European specimens from the mountain limestone of England or Belgium. The specimen, fig. 8, in which the shelly layer has been well preserved, exhibits the characteristic ornamentation, marked by numerous, very thin, radiating striæ, which are arranged between the more distant concentric lines. The reticulation is never so distinct as in the Indian specimens, which have been figured by Waagen.

The measurements of two specimens (Pl. IX, figs. 5 and 8) are as follows:—

	I (fig. 5).	II (fig. 8).
Entire length of the shell	29 mm.	23 mm.
Length of the dorsal valve	23 "	18.5 "
Entire breadth of the shell	29 "	19.5 "
Length of the hinge line	17 "	12 "
Thickness of both valves	20.5 "	15 "
Apical angle of the ventral valve	90°	70°
" " " " dorsal "	?	120°

I have not been able to ascertain the internal characters in any of the Tibetan specimens.

Number of specimens examined.—7.

Remarks.—*Reticularia lineata* is a very common and widespread species ranging from the lowest carboniferous into permian strata. In Great Britain it ranges from the lower limestone shales into the millstone grit, whilst in Belgium it is most abundant in the Calcaire de Visé. It is known from the mountain limestone of Alsatia, Central France and Silesia. Möller, de Verneuil, Grunewaldt, Trautschold and Nikitin quote it from the carboniferous deposits of Russia. Tschernyschew discovered it in the Artinskian marls of permocarboniferous age, Schellwien in the upper carboniferous Fusulina limestone of Carinthia. In the eastern region it has been mentioned from the permian strata of Julfa by Abich; from the upper carboniferous rocks of Loping by Kayser, and of Tongitar in the Koptan Range by E. Suess, who discovered it in the collections made by Dr. Stoliczka; from the lower Productus limestone of the Salt Range by Waagen from the permian rocks of Timor by Beyrich and Rothpletz.

A somewhat doubtful fragment (ventral valve) from Barents Island (Novaya Semlya) has been described as *Spirifer lineatus*, Mart. var., by Toula (Sitzgsber. K. Akad. Wiss. Wien, LXXI, I. Abth., 1875, p. 19, Pl. II, fig. 3). L. de Koninck (Recherches sur les fossiles paléozoques de la Nouvelle-galles du Sud, Bruxelles, 1876-77, 3 ptie, p. 224, Pl. XI, fig. 9) figures a ventral valve from the carboni-

ferous strata of New South Wales, which he identifies with *Spirifer lineatus*, Mart., but it is impossible to decide from the figure whether the Australian form is identical with the European and Indian types of *Reticularia lineata*.

According to Waagen the presence of the true *R. lineata* in America is very doubtful. The smaller species, which has been called *R. perplexa* by McChesney (Descr. New Palæozoic Fossils, 1860, p. 43), must at all events be kept separate.

A species, which I am likewise inclined to consider as specifically distinct from the present form, is *R. conularis*, Grunewaldt (Beiträge zur Kenntniss der sedimentären Gebirgsformationen, etc., Mém. Acad. Imp. Sci. St. Pétersbourg, sér. vii, II, No. 7, 1860, p. 102, Pl. IV, fig. 2) although Trautschold quotes it partially among the synonyms of *R. lineata* and of *Martinia glabra*. According to Grunewaldt's description, the most important feature in the species from the Ural Mountains is the extraordinary disproportion in the size of its valves, the ventral valve being about three times as deep as the dorsal one. Neither in this character nor in the shape of the strongly elongated beak do any of my specimens agree with Grunewaldt's type specimen from Artinsk:

Family: *ATHYRIDÆ*, Phillips.

Sub-family: *ATHYRINÆ*, Waagen.

Genus: *ATHYRIS*, M'Coy. (*SPIRIGERA*, d'Orbigny.)

1. *ATHYRIS ROYSSII*, Léveille. Pl. X, figs. 1, 2, 3, 6.

1835. *Spirifer de Royssii*, Léveille, Mém. Soc. Géol. France, II, p. 39, Pl. II, figs. 18—20.
 1843. *Terebratula Royssii*, de Koninck, Description des animaux fossiles qui se trouvent dans le terrain carbonifère de Belgique, p. 300, Pl. XXI, fig. 1.
 1858. *Athyris Royssii*, Davidson, Monograph British Carbon. Brachiopoda, p. 87, Pl. XVIII, fig. 1—11.
 1862. *A. Royssii*, Davidson, Quart. Journ. Geol. Soc., London, XVIII, p. 27, Pl. I, fig. 6.
 1863. *A. Royssii*, Davidson in L. de Koninck, Mém. sur les fossiles Paléozoïques, recueillis dans l'Inde, p. 33, Pl. IX, fig. 6.
 1865. *Spirigera Royssii*, Beyrich *ex parte*, Ueber eine Kohlenkalkfauna von Timor, Abhandl. K. Akad. d. Wissensch., Berlin, 1864, p. 74, Pl. I, fig. 3. (*non* 2).
 1863. *Athyris Royssii*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 475, Pl. XL, fig. 6—12, Pl. XXXIX, fig. 10.
 1897. *A. Royssii*, Diener, Himalayan Fossils, Palæontologia Indica, ser. xv, I, Pt. 4, Pl. V, figs. 5, 7.

In my memoir on the fauna of the Himálayan Productus shales I have fully explained my intention in giving this specific name to the Himálayan specimens. Waagen has distinguished among his group of *Athyris Royssii* quite a number of forms, to which he applied specific denominations. Although I agree with Rothpletz (Palæontographica, XXXIX, 1892, p. 81) in considering these distinctions, on rather insignificant characters, of no great importance, I do not object to accepting Waagen's species, as I can easily distinguish them among the Tibetan material.

The overwhelming majority of specimens, which have been collected in the permocarboniferous limestone of Chitichun No. I, belong to Waagen's *Athyris*

Royssi typica. They agree very well both with Waagen's types from the Salt Range and with the permian specimens from the Productus shales of Jobár and Painkhánda. The three figures given in this memoir show the amount of variability among the Tibetan types. Their general outline is either circular or slightly subpentagonal (Pl. X, fig. 1). As a rule the transverse diameter is a little larger than the longitudinal one. The valves are comparatively flat. Specimens which are more strongly vaulted than that figured on Pl. X, fig. 3, are rare.

Neither the sinus in the ventral and the corresponding median fold in the dorsal valve are ever very conspicuous, and in some of the specimens (Pl. X, fig. 2) even entirely absent. But even in such specimens a flat frontal wave is indicated. The foramen of the beak is rather variable in size, but, as a rule, larger than in Beyrich's specimen from the Island of Timor.

The ornamentation of the shell is of exactly the same pattern, as has been noticed by Waagen in his Indian specimens.

In the example figured on Pl. X, fig. 6, the internal characters are partly accessible to observation, a portion of the spinal appendages having been laid bare.

My specimens do not attain as large dimensions as those which have been figured by Davidson from the British mountain limestone. The largest example nearly attains the same size as the one figured by Waagen on Pl. XL, fig. 8, of his memoir, but is considerably flatter. The measurements of two smaller specimens (Pl. X, figs. 2 and 3) are as follows:—

	I (fig. 2).	II (fig. 3).
Entire length of the shell	28.5 mm.	29 mm.
Length of the dorsal valve	27 "	27.5 "
Entire breadth of the shell	31 "	31 "
Thickness of both valves	15 "	19 "
Apical angle of the ventral valve	115°	107°
" " " " dorsal " 	121°	119°

Number of specimens examined.—117.

Remarks.—*A. Royssi* is by far the most common shell in the permian-carboniferous limestone of Chitichun No. I. In the Salt Range it is likewise largely distributed through the middle and upper divisions of the Productus limestone, while it is very rare in the lower Productus limestone. Waagen considers his Indian specimens as absolutely identical with the typical forms from the mountain limestone of Europe. L. de Koninck (*Faune du calcaire carbonifère de la Belgique*, Ann. Mus. Roy. d'Hist. Nat. Bruxelles, XIV, 1887, pt. 6, p. 85) does not share in this view, but believes all the shells from upper carboniferous and permian strata, which have been classed by palæontologists among the synonyms of *A. Royssi*, to be specifically different from Lèveillé's species.

The Indian *A. Royssi* is certainly identical with the types from the permian Productus shales, from Timor and from Chitichun No. I. Whether the specimen from the permian rocks of Julfa, which has been described and figured by Abich (*Geologische Forschungen in den kaukasischen Ländern*, I. Th. Eine Bergkalk fauna aus der Araxesenge bei Djoulfa, p. 62, Pl. VII, fig. 8) as *Athyris*

Royssii, belongs to this species, even in the wider definition adopted by Waagen, is, to say the least, very doubtful.

2. *ATHYRIS SUBEXPANSA*, Waagen. Pl. X, fig. 4.

1883. *Athyris subexpansa*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 478, Pl. XXXIX, figs. 1—5.

The only specimen among the material from Chitichun No. I, which I am able to identify with the present species, agrees perfectly well with Waagen's description and figures. In its transversely oval outlines and in its comparatively flat shape it especially recalls Waagen's specimen from Musakheyl (loc. cit. Pl. XXXIX, fig. 4), but in the characters of the sinus it approaches more nearly his example from Kálábagh (fig. 3). The sinus is very shallow and indicated only in the proximity of the front, causing the middle portion of the frontal part to be slightly bent up. In this respect my specimen is most nearly related to *A. expansa* Phill. (Davidson, Mon. Brit. Carb. Brach., p. 82, Pl. XVI, figs. 14, 16, 18; XVII, figs. 1—5).

I am really at a loss how to distinguish the latter species, from the mountain-limestone of Western Europe, from Waagen's *A. subexpansa*. The two characters which, according to Waagen's diagnosis, ought to serve for their distinction, namely, the presence of a well developed sinus in the ventral valve and the fringed expansions of the Indian form, do not seem to be constant features. The two specimens figured by Waagen on Pl. XXXIX, figs. 2 and 3 of his memoir, have only a very shallow sinus. On the other hand, Davidson in his description of *Athyris expansa* states the ventral valve to be occasionally provided with a gentle median depression. Nor do the fringed lamelliform expansions in the sculpture of the shell seem to be entirely absent in the European form, so far as we may judge from Sowerby's description and figures in his Mineral Conchology (Pl. DCXVI, fig. 1). It is, however, true, that the median depression is extremely shallow in the specimens figured by Davidson. Thus a distinction of the two species may possibly be based on this insignificant feature.

Of the ornamentation of the shell I can say but little. The numerous, imbricating striæ of growth are present, as in most of the congeneric forms, but I have not been able to verify Waagen's observation regarding the shelly fringes, the uppermost layer of the shell in my specimen having been injured by weathering.

The measurements are as follows :—

Entire length of the shell	. . . . .	25 mm.
Length of the dorsal valve	. . . . .	23.5 "
Entire breadth of the shell	. . . . .	32 "
Thickness of both valves	. . . . .	15 "
Apical angle of the ventral valve	. . . . .	125°
" " " " dorsal "	. . . . .	134°

Number of specimens examined.—1.

Remarks.— Waagen quotes *A. subexpansa* from the middle and upper divisions

of the Salt Range Productus limestone. It is most abundant in the Virgal and Kálábagh beds, but very rare in the Katta beds of the middle Productus limestone. Whether it is also present in the upper carboniferous or permocarboniferous deposits of Russia cannot be determined, as no figures of *A. Royssii* have been given by Tschernyschew and Nikitin, who quote the latter species from Central Russia and from the Ural Mountains.

3. *ATHYRIS CAPILLATA*, Waagen. Pl. X, fig. 5.

1883. *Athyris capillata*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 479, Pl. XXXIX, figs. 6–9; Pl. XL, figs. 1–5; Pl. XLII, figs. 1–5.

1892. *Spirigera Royssii* var. *capillata*, Rothpletz, Die Perm- Trias- und Juraformation auf Timor und Rotti, Palæontographica, XXXIX, p. 81, Pl. X, fig. 2.

There is only one fragmentary specimen in the Tibetan collection, which exhibits the characteristic ornamentation of this species, and may consequently be kept separate from Waagen's *Athyris Royssii typica*. The shell is of a nearly circular outline. Its valves are more strongly inflated than in the majority of the specimens of *A. Royssii*. The mesial depression in the ventral valve is shallow, but distinctly indicated. The very large number of lamellar striæ of growth, which are covered with thickly set hair-like fringes, is a good character of this species.

The measurements of my specimen are as follows:—

Entire length of the shell	. . . . .	25·5 mm.
Length of the dorsal valve	. . . . .	24 „
Entire breadth of the shell	. . . . .	28 „
Thickness of the two valves	. . . . .	16 „

Number of specimens examined.—1.

Remarks.—*Athyris capillata* has been quoted by Waagen from the middle and upper divisions of the Salt Range Productus limestone, where it is very common. It has not been collected either in the lower Productus limestone, or in the Katta beds of the middle Productus limestone. Rothpletz discovered the species in the collections, which have been made by Wichmann in the permian rocks of the island of Timor.

Subgenus: *SPIRIGERELLA*, Waagen.

The genus *Spirigerella* was introduced by Waagen (Pal. Indica, ser. xiii, I, p. 450) for such species of *Athyrinæ*, as differ externally from *Athyris*, M'Coy (*Spirigera*, Orb.) in the shape of their apical region, the beak being bent over so strongly and appressed to the apex of the dorsal valve, that the small foramen of the beak is entirely concealed. Internally the shape of the cardinal process and the mode of attachment of the primary lamellæ mark a character of distinction of *Athyris*. Rothpletz (Palæontographica, XXXIX, 1892, p. 82) does not consider these characters of generic importance. Oehlert (in Fischer, Manuel de Conchyliologie, III, p. 1299) and Zittel (Grundzüge der Palæontologie, 1895, p. 240) do, however, accept *Spirigerella* as a subgenus of *Athyris*. In the present memoir I have followed the views of these two learned authors.

In the permocarboniferous limestone of Chitichun No. I, *Spirigerella* is represented by three species. Two among them are identical with forms, which have been previously described from the middle and upper divisions of the Salt Range Productus limestone.

1. SPIRIGERELLA DERBYI, Waagen. Pl. XI, fig. 4.

1883. *Spirigerella Derbyi*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 753, Pl. XXXV, figs. 4-7, 9-13; Pl. XXXVII, figs. 11-13; *var. acuteplicata*, p. 756, Pl. XXXV, figs. 10, 11, Pl. XXXVII, fig. 11.

For further synonyms *vide* my monograph of the fossils of the Productus shales (Pt. iv of the present volume).

There is a solitary specimen among the material from Chitichun No. I, which, according to my opinion, must be identified with this species. In its dimensions it approaches most nearly the types, figured by Waagen under the varietal denomination *acuteplicata* (especially Pl. XXXV, fig. 10), or the specimens from the permian Productus shales (Pt. iv of the present volume, Pl. V, figs. 6, 8). It is of the same size, a little longer than broad, and provided with a broad median fold in the dorsal valve, to which an equal sinus in the ventral valve corresponds. This sinus originates in the frontal portion of the latter valve only, and is only as deep, as in the typical form of the Salt Range species. The beak is entirely appressed to the apical region of the dorsal valve, its foramen being therefore absolutely concealed. A tongue-shaped process is formed in the frontal region by the different breadth of the shelly zones in the frontal and lateral portions of the ventral valve, as it has been likewise noticed by Waagen in his types from the Salt Range.

The surface of the well preserved shell is entirely smooth.

The measurements of this specimen are as follows :—

Entire length of the shell	. . . . .	16 mm.
Length of the dorsal valve	. . . . .	13.5 "
Entire breadth of the shell	. . . . .	14 "
Thickness of both valves	. . . . .	10 "
Apical angle of the ventral valve	. . . . .	88°
" " " " dorsal "	. . . . .	110°

Number of specimens examined.—1.

Remarks.—*Spirigerella Derbyi* is peculiar to permocarboniferous and permian strata. It is one of the most common fossils in the Virgal and Kálábagh beds of the middle Productus limestone and in the upper Productus limestone of the Salt Range. In the Himálayas it has been collected by Griesbach in the permian Productus shales of Painkhánda. In America it occurs in the coalmeasures of Itaituba (Brazil), which, according to Waagen, ought to be correlated with the upper divisions of the middle Productus limestone.

The shape of the sinus does not allow an identification of the present species with Waagen's *Sp. Derbyi var. acuteplicata*.

2. *SPIRIGERELLA GRANDIS* (Davidson), Waagen. Pl. XI, fig. 3.

1862. *Athyris subtilita*, Hall, var. *grandis*, Davidson, Quart. Journ. Geol. Soc., London, XVIII, p. 28 Pl. I, fig. 8 (7).
 1863. *Athyris subtilita* var. *grandis*, Davidson, in L. de Koniuck, Mémoire sur les fossiles paléozoïques recueillis dans l'Inde, p. 33, Pl. IX, fig. 8.
 1883. *Spirigerella grandis*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 461, Pl. XXXVI, figs. 1-7; XXXVII, fig. 1.

The Tibetan specimens do not vary so much, in shape and dimensions, as the representatives of this species in Salt Range Productus limestone, which have been figured by Waagen. The reason may, however, be found in the fact, that I had to deal with a rather small number and with adult individuals only.

All are distinguished by a suborbicular shape, strongly inflated valves, a distinctly appressed beak, the foramen of which is very small and entirely concealed, and by the presence of a very shallow sinus. In the latter character they agree with the examples from Musakheyl, figured by Waagen on Pl. XXXVI, figs. 3, 4. Both in the longitudinal and in the transverse direction the curve of the two valves is very equal. The frontal part is not produced.

The ventral valve is about as deep as the dorsal one, and provided with a comparatively small, strongly incurved beak, which is bordered on both sides by a very indistinct false area. The shallow depression, which corresponds to the sinus, is confined to the proximity of the front. In the dorsal valve no median fold has been observed. Waagen describes the lateral margins of this valve as "hanging down laterally over the margins of the ventral valve in full grown specimens, thus enveloping them more or less." I have noticed this character in several of my specimens, though only in a slight degree.

The ornamentation of the two valves consists of numerous imbricating striæ of growth, which occur at irregular distances. In places, where the fibrous shell has been injured by weathering, very numerous but extremely thin, radial striæ make their appearance within the zones, which are marked off by two lines of growth.

In its general shape this species recalls *Athyris globulinc*, Waagen (p. 487, Pl. XLI, figs. 1-3), but it is considerably larger and the rounded foramen, as it is exhibited in the latter form, is not visible in any of my specimens.

The dimensions of my largest specimen are as follows:—

Entire length of the shell	30 mm.
Length of the dorsal valve	27 "
Entire breadth of the shell	26 "
Thickness of the two valves	21 "
Apical angle of the ventral valve	95°
" " " " dorsal "	107°

Number of specimens examined.— 4

Remarks.—In the Salt Range *Spirigerella grandis* is almost entirely restricted to the middle division of the Productus limestone. Among 46 specimens examined by Waagen, there was only a single one from the upper division. In the middle Productus limestone it is common both in the Virgal and Kálábagh beds, but does not descend into the Katta beds.

3. *SPIRIGERELLA PERTUMIDA*, nov. sp. . Pl. XI, figs, 1, 2.

This species, which is represented by two specimens only, stands in a similar relationship to *Spirigerella grandis*, Waagen, or to *Sp. media*, Waagen, as does *Reticularia conularis*, Grunewaldt, to *R. lineata*, Mart. It differs from all the hitherto described species of the subgenus *Spirigerella* in the very strong development of the apical region in the ventral valve. The greatest thickness of the two valves coincides with the cardinal region.

The ventral valve is as deep or a little deeper than the opposite one. It is almost equally curved in the longitudinal direction, perhaps slightly more strongly in the apical than in the frontal region. Transversely the bend is very steep in the proximity of the margins, but becomes rather flat in the central portion of this valve.

The apex is enormously inflated and strongly bent over. The beak is pointed and firmly appressed to the apex of the dorsal valve, its small foramen being thus entirely concealed. It is bordered on both sides by a comparatively large false area, which is not, however, marked off distinctly from the remainder of the shell. Laterally it is not overlapped by the margins of the dorsal valve, as is often the case in full grown individuals of *Sp. grandis*. The frontal part of the valve is strongly produced. Of the two type specimens the one, which is distinguished by its more elongated shape, is provided with only a very shallow median sinus, whereas in the second the sinus is well developed and originates in the apical region, extending for about three quarters of the entire length of the valve.

The dorsal valve is more strongly curved in the transverse than in the longitudinal direction. The median fold is developed as a sort of an obtusely rounded crest, in which the lateral parts of this valve unite, enclosing a right angle. This median crest originates in the very apex, but is only developed into a fold in the frontal region. This fold is neither very prominent nor rectangular. A small part of the apical region only is concealed below the beak of the ventral valve.

The ornamentation of the two valves is the same as in *Sp. grandis*, or in *Sp. Derbyi*. The shell is fibrous in its structure, which is well exhibited in a portion of the dorsal valve of the specimen figured Pl. XI, fig. 1.

Of the interior characters nothing, unfortunately, is known to me. The only feature, I have been able to observe, is the enormous thickness of the ventral valve in the apical region, reminding me of Waagen's description of *Spirigerella grandis* (loc. cit, p. 462).

The measurements of the two type specimens are as follows:—

	I (fig. 1).	II (fig. 2).
Entire length of the shell	33 mm.	33 mm.
Length of the dorsal valve	24 "	24.5 "
Entire breadth of the shell	30 "	27 "
Thickness of both valves	23 "	20 "
Apical angle of the ventral valve	?	app. 70°
" " " dorsal "	120°	120°

Number of specimens examined.—2.

Remarks.—It appears to me, that the characters, which have been enumerated in the preceding diagnosis, especially the extraordinary inflation of the apical region in the ventral valve, are sufficient to distinguish this form from the hitherto described congeneric species.

This species is certainly nearly allied to *Spirigerella grandis*, Waagen, or perhaps still more nearly to *Sp. timorensis*, Rothpletz (Die Perm- Trias- und Jura-formation auf Timor und Rotti, Palæontographica, 1892, XXXIX, p. 82, Pl. X, figs. 4, 5). My specimens differ, however, from the figures of *Sp. timorensis*, given by Rothpletz, not only in the more strongly inflated apices of the ventral valve, but also in the fact, that a considerably smaller part of the apical region in the dorsal valve is concealed by the beak of the opposite one. Among the numerous types of *Spirigerella* from the permian rocks of Julfa, which have been united with true *Athyris* in one single species, *Spirigera protea*, by Abich (Geologische Forschungen in den Kaukasischen Ländern, I. Th. Eine Bergkalk-Fauna aus der Araxesenge bei Djoulfa, Wien, 1878, p. 52) there is especially the one figured on Pl. VII, fig. 7 of his memoir, which recalls *Spirigerella pertumida*. It has been described by Abich (loc. cit., p. 58) as *Spirigera protea* var. *globularis*, Phill. That it must be kept separate from the true *Spirigera* (*Athyris*) *globularis*, Phill., has been proved by von Möller (Neues Jahrbuch, 1879, p. 225). It is probably identical with *Spirigerella timorensis*, Rothpletz, a species, which this author himself believes to be represented among the variations of Abich's *Sp. protea*. An identification of this Armenian form with *Sp. pertumida*, is, however, impossible in spite of their general resemblance. In the specimen from Julfa the greatest thickness of the two valves is situated about half way between the front and the cardinal region, and the difference between the entire length of the shell and of the dorsal valve is only one sixth of the former, whereas it is more than one quarter in the Tibetan species.

Suborder ANCISTROPEGMATA, Zittel.

Family : *PORAMBONITIDÆ*, Davidson.

Subfamily: ENTELETINÆ, Waagen.

Genus: ENTELETES, Fischer v. Waldh. (SYNTRIELASMA, Meek.)

The genus *Enteletes* is represented in the permocarboniferous fauna of Chitichun No. I, by a new species, belonging to the section of *ventrisinuati*, Waagen, in which the ventral or smaller valve is provided with the sinus, and the dorsal or larger valve bears the corresponding median fold. To this series of forms, the typical one of the genus, belong *E. Lamarcki*, Fischer v. Waldh., *E. Kayseri*, Waagen, *E. hemiplicatus*, Hall, *E. lævissimus*, Waagen, *E. carnicus*, Schellwien. My new species, which will receive the name of *E. Tschernyscheffi*, is very nearly

related to *E. Kayseri*, and belongs to a group of forms of which *E. hemiplicatus*, Hall, is the prototype.

1. ENTELETES TSCHERNYSCHIEFFI, nov. sp. . Pl. V, figs. 7-11.

This is a rather large species of slightly transversely oval or nearly circular outlines, and strongly inflated valves, of which the dorsal one is considerably larger and more strongly vaulted.

The ventral valve is provided with a comparatively short, little prominent, moderately incurved apex, and with a high and concave area, which is cut open in the middle by a large triangular fissure. The median sinus originates in the apical region. In full grown specimens (fig. 9), it may be traced almost to the very apex of the valve. It is angular and bordered on both sides by high and tolerably sharp folds, which are followed on each side by three other folds. In some specimens a fourth fold is slightly indicated. These lateral folds likewise originate in the proximity of the apex.

The dorsal valve, which is the larger one, is of a nearly semicircular shape. Its strongly incurved apex distinctly overhangs the hinge line, which equals only one half the entire breadth of the shell in length. The area is considerably lower than in the opposite valve, but likewise cut open in the middle by a large deltidial fissure. In this valve a strong median fold, originating in the apical region, corresponds to the sinus of the ventral valve. It is followed on each side by three or occasionally even by four lateral folds. The median fold is the broadest and highest of all, the lateral folds gradually diminishing in height and breadth. The crests of the folds as well as the median edges of the angular valleys between them are tolerably sharp.

The front margin of both valves forms a deeply and sharply zig-zag shaped line. Numerous striæ of growth, which are bent up and down in similar zig-zag lines, cover the surface of the two valves in the vicinity of the front. In well preserved specimens (fig. 11) a delicate, radial striation may be noticed.

Of the internal structure of this species I have only been able to make out traces of the three septa in the ventral valve.

The present species attains very considerable dimensions. As far, as we may judge from the size of the smaller valve, figured on Pl. V, fig. 8, it is not much surpassed in this respect by *E. pentameroides*, Waagen, or by *E. Suessi*, Schellwien, the largest hitherto known species of this genus.

The measurements of a moderately sized but fairly complete specimen are as follows:—

Entire length of the shell	. . . . .	20 mm.
Length of the dorsal valve	. . . . .	18 "
Entire breadth of the shell	. . . . .	22.5 "
Length of the hinge line	. . . . .	11 "
Thickness of both valves	. . . . .	19.5 "
Height of the area of the smaller valve	. . . . .	1.5 "
Apical angle of the smaller valve	. . . . .	116°
" " " " larger "	. . . . .	102°

Number of specimens examined.—11.

Remarks.—The present species seems to be very closely related to *E. Kayseri*, Waagen (= *E. hemiplicatus*, Kayser non Hall, Obercarbonische Fauna von Loping, Richthofen's China, IV, p. 179, Pl. XXIV, figs. 2, 3) from the upper-carboniferous rocks of Loping. As may be seen from the figures and descriptions given by Kayser, Waagen (Pal. Indica, ser. xiii, I, p. 553), and Schellwien (Palæontographica, 1892, XXXIX, p. 35), these two species bear a strong resemblance, and must certainly be united in the same group of forms. Nevertheless the Tibetan species can be easily distinguished from *E. Kayseri* by its more globular profile and by the strong plication of its valves. In *E. Kayseri* the number of lateral folds is always smaller, and both the folds and the median ridges in the intercostal valleys are neither so sharp nor do they extend so near the apical region, as in the present form. The remarkably flatter shape of the dorsal valve in *E. Kayseri* is also a good character of distinction.

There is no other species yet known from the section of the *ventrisinuati*, to which *E. Tschernyscheffi* could be more particularly compared. It is, however, very similar, if not actually identical, with a yet undescribed species from the permian rocks of Sicily, which the palæontological museum of the Vienna University has quite recently been able to acquire.

This beautiful species is dedicated to Prof. Tschernyschew of St. Petersburg, who by his geological work in the Ural Mountains contributed so considerably to our knowledge of the palæozoic faunas of Russia.

Family : *RHYNCHONELLIDÆ* Gray.

Subfamily : *RHYNCHONELLINÆ*, Waagen.

Genus : *UNCINULUS*, Bayle.

Although representatives of the genus *Rhynchonella*, Fisch., are not altogether absent from the permocarboniferous limestone of Chitichun No. I, they are extremely rare. Among the extensive material I have only found two specimens, which may be attributed to this genus, and they are in a too fragmentary state of preservation to allow any specific determination. It is a rather astonishing fact that the family of *Rhynchonellidæ* is almost exclusively represented, in the Chitichun limestone, by the genus *Uncinulus*, which has been met with hitherto but very rarely, and in rather sporadic specimens only, in beds of a similar geological age. To this genus a species belongs, which I believe to be identical with Beyrich's *Rhynchonella timorensis* from the island of Timor, and which is not at all rare in the Chitichun limestone.

1. *UNCINULUS TIMORENSIS*, Beyrich. Pl. X, figs. 7, 8, 9, 10.

1865. *Rhynchonella Timorensis*, Beyrich, Ueber eine Kohlenkalk-Fauna von Timor, Abhandlg. K. Ak. Wiss., Berlin, 1864, p. 72, Pl. I, fig. 10.
 1883. *Uncinulus Theobaldi*, Waagen, Palæontologica Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 425, Pl. XXXIV, fig. 1.
 1892. *Rhynchonella (Uncinulus) Timorensis*, Rothpletz, Die Perm- Trias- und Juraformation auf Timor und Rotti, Palæontographica, XXXIX, p. 87, Pl. X, fig. 6.

Beyrich based his diagnosis of this interesting species on a single specimen from the Ajermati river near Kupang on the island of Timor. Among Wichmann's collections from the same locality Rothpletz likewise discovered a single specimen of this species. Waagen introduced the name *U. Theobaldi* for two specimens from the Productus limestone of the Salt Range, which, though resembling *U. timorensis* very much, seemed to differ from the latter in some minor details. Rothpletz suggested that both *U. Theobaldi* and *U. jabiensis*, Waagen (Pl. XXXIV, fig. 2, p. 427) ought to be united with *U. timorensis* until their characters of difference, which are all within the limits of variations of a species, have been proved constant by the comparison of more material. My examination of a large number of specimens has convinced me, that *U. timorensis* and *U. Theobaldi* at least ought no longer to be maintained as separate species, as they do not differ by constant characters.

The points of difference, which Waagen considered to be of specific value, are the following: *Uncinulus timorensis* is distinguished by the greater smoothness of the shell, the smooth part in the cardinal region of *U. Theobaldi* being considerably smaller, by the far broader median fold and sinus in comparison to the lateral parts and by the greater flatness or the nearly impressed form of the ventral valve.

Among my specimens both the typical forms of *U. timorensis* and of *U. Theobaldi* are represented, but linked together by a considerable number of intermediate types uniting one or more of the above mentioned characters, which Waagen believed to be of specific importance. The specimen figured on Pl. X, fig. 8, perfectly agrees with the typical *U. Theobaldi*. The lateral parts and the median portion of the shell are of nearly equal breadth, the ventral valve is flatly arched, not impressed, the ribs cover nearly half the extent of the valve. In the specimen fig. 7, the ribs are considerably shorter, the smooth part occupying more than one half of the entire length of the ventral valve. But this distinction, which is based on the length of the ribs, loses all its importance from the fact, that in some of my specimens the ribs, although thinning very gradually, extend even as far into the apical region, as in *Uncinulus posterus*, Waagen (loc. cit., p. 428).

It will also be found that in different examples the breadth of the median portion, corresponding to the mesial fold and sinus, varies considerably. In the specimen fig. 10, the median part of the shell is more than twice as broad as the lateral portions, a proportion, which perfectly agrees with that noticed in Beyrich's type specimen. Nor is the shape of the ventral valve a more constant character. In the specimen fig. 9, it is barely less distinctly impressed than in the typical *U. timorensis*.

Of other variations the following may be mentioned: The shelly rectangular lobe, into which the median part of the ventral valve is prolonged, is very variable in its height, and bordered on both sides by either vertical or very steeply inclined margins. The number of ribs is also variable. I counted from eight to twelve ribs in the sinus or corresponding fold and an equal or larger number in the lateral portions of the shell.

My examination of the fossil material in the Tibetan collection has convinced me, that Waagen's illustration of *Uncinulus Theobaldi*, is only one of the numerous modifications, assumed by this variable species. After the discovery of so many intermediate shapes it has appeared to me impossible to arrive at any other satisfactory conclusion, than that they are all variations of *U. timorensis*. Both species apparently merge into each other so completely, that I cannot help considering them as specifically inseparable.

I am not, however, inclined to add *Uncinulus jabiensis*, Waagen (loc. cit., p. 427, Pl. XXXIV, fig. 2) to the synonyms of *U. timorensis*, as has been advocated by Rothpletz. All my specimens of *U. timorensis* are transversely oval and much shorter than broad. I have never met with a single type among them, representing the triangular outlines of *U. jabiensis*, or *U. posterus*. I therefore believe the transversely oval shape of *U. timorensis*, to be a good and constant character of specific importance. The number of ribs in *U. jabiensis* is also considerably smaller than in any of my examples of the present species.

It is barely necessary to add anything else to Waagen's excellent description of *U. Theobaldi*. Regarding the internal structure of the species, I may only remark, that besides the tolerably large dental plates in the ventral valve a median septum has been noticed in the dorsal valve.

My largest specimen attains a diameter of 28 mm. The measurements of a median sized specimen are as follows:—

Entire length of the shell	. . . . .	15 mm.
Length of the dorsal valve	. . . . .	13.5 "
Entire breadth of the shell	. . . . .	20 "
Thickness of both valves	. . . . .	12 "
Apical angle of the ventral valve	. . . . .	113°
" " " " dorsal "	. . . . .	app. 120°

Number of specimens examined.—28.

Remarks.—The present species has been described both from the Kálábagh beds of the middle Productus limestone and from the Jabi beds of the upper Productus limestone in the Salt Range by Waagen, and from the permian rocks of Timor by Beyrich and Rothpletz.

Lóczy (Wissenschaftliche Ergebnisse der Reise des Grafen Béla Széchenyi, I Th. Wien, 1893, p. 723) quotes the species from beds of a probably permocarboniferous age near Yar-ka-lo in South-Eastern China.

Subfamily : CAMAROPHORIINÆ, Waagen.

Genus : CAMAROPHORIA, King.

This characteristic and easily recognisable genus is represented in the permocarboniferous fauna of Chitichun No. I, by three species, all of which belong to the group of *Camarophoria crumena*, Mart. Of these three species only one can be identified with a well known Salt Range form *C. Purdoni*, Davidson. The second, although very nearly related to *C. Purdoni*, must be considered as new species distinguished by its unusually large size and by the larger number of ribs, covering both valves. The third species is too imperfectly preserved to allow an exact determination.

1. CAMAROPHORIA PURDONI, Davidson. Pl. XII, figs. 6, 8, 9.

1862. *Camarophoria Purdoni*, Davidson, Quart. Journ. Geol. Soc. London, XVIII, p. 30, Pl. III, fig. 4.
 1863. *Camarophoria Purdoni*, Davidson, in L. de Koninck, Mémoire sur les fossils paléozoïques recueillis dans l'Inde, p. 36, Pl. XII, fig. 4.
 1883. *C. Purdoni*, Waagen, Salt Range Fossils, ser. xiii, Palæontologica Indica, I, Productus Limestone Fossils, p. 437, Pl. XXXII, figs. 1-7.
 1890. *C. Purdoni*, Nikitin, Mémoires. Com. Géol. Russ., St. Pétersbourg, V, No. 5, p. 71, Pl. III, figs. 6-7.

This species is very common in the permocarboniferous limestone of Chitichun No. I.

The specimens do not vary greatly in their general shape and outlines. The majority among them are transversely oval, but examples are not at all rare in which the length and breadth of the shell are nearly equal. The valves are either strongly or moderately inflated. Flat specimens, like the one figured on Pl. XII, fig. 9, are quite an exception. Both valves are convex, but the dorsal valve is always much more strongly vaulted. The sinus in the ventral valve is rather broad, always broader than the lateral parts, but not deeply sunk in. The beak is well incurved and pointed, but it is very rarely sufficiently well preserved to exhibit the triangular slit at its lower side.

The ventral valve is covered with sharply rounded ribs of a rather irregular strength and number. They originate in the proximity of the very apex, leaving a very small portion of the shell only entirely smooth. This is a good character of distinction between the present species and *C. crumena*, Mart, or *C. pinguis*, Waag., in which the ribs are always restricted to the frontal, marginal and central portions of the shell, whereas the cardinal region is quite smooth. In average sized specimens there are from ten to eighteen ribs present in this valve. There are from five to seven ribs within the sinus. On the lateral parts of the valve the number of ribs is rarely equal on both sides of the sinus. Like Waagen's types from the Salt Range the Tibetan specimens show a remarkable tendency to become unsymmetrical.

The augmentation of ribs in full grown specimens is always due to the intercalation of new ribs, not to a bifurcation of the original ones, which remain undivided from the apical region to the front.

The dorsal valve is distinctly subdivided into three portions, of which the median one is very broad, but not much elevated, rounded and slightly flattened on its top. The sculpture is of the same pattern as in the opposite valve, but the number of folds is, as a rule, a little larger.

Traces of expansions have been noticed on the frontal and lateral margins of several specimens.

The internal characters of the Tibetan examples agree perfectly with Waagen's and Nikitin's descriptions and figures. They are, as a rule, better exhibited in the ventral than in the dorsal valve. The strong median septum is fixed to the dental plates so as to leave an ogival interval between the latter. In the dorsal valve both the high median septum and the spathulate, trilobate plate have been observed.

The measurements of an average sized specimen are as follows :—

Entire length of the shell	. . . . .	26 mm.
Length of the dorsal valve	. . . . .	23.5 "
Entire breadth of the shell	. . . . .	32 "
Breadth of the median fold	. . . . .	16 "
Thickness of both valves	. . . . .	18 "
Apical angle of the ventral valve	. . . . .	98°
" " " " dorsal "	. . . . .	112°

Number of specimens examined.—51.

Remarks.—There cannot, I think, be much doubt as to the identity of the Tibetan specimens with Davidson's species, as they agree with the latter not only in their more important characters, but also in their minor details.

The only other species, with which they might be compared, is *Camarophoria alpina*, Schellwien (Palæontographia, XXXIX, 1892, p. 51, Pl. VIII, figs. 4-8), which only differs from *C. Purdoni* in very minor details, but the number and arrangement of ribs in the Tibetan examples is more in accordance with Davidson's Indian species.

In the Salt Range *Camarophoria Purdoni* is very common in the Virgal and Kálábagh beds of the middle Productus limestone, but very rarely extends into higher strata. Nikitin quotes the species from the Gshelian stage of the upper carboniferous deposits of Central Russia. He likewise refers *C. plicata*, Tschernyschew (Mém. Com. Géol. Russ., St. Pétersbourg, III, No. 4, p. 369) from the Artinskian horizon of the Ural Mountains to *C. Purdoni*.

2. CAMAROPHORIA GIGANTEA, nov. sp. . Pl. XII, figs. 5, 7, 10.

From *Camarophoria Purdoni* a species must be separated, which, although very nearly related to the former, is readily distinguished by its very remarkable size and by the larger number of ribs in both valves. This species attains gigantic dimensions, surpassing largely in size all the types of *C. Purdoni*, which have been figured by Davidson, Waagen and Nikitin. Nor can any intermediate types be traced between the two forms.

In their general shape and outlines the two species agree perfectly with each other. The only difference consists in the sculpture, which is formed by a larger

number of ribs in *C. gigantea*. The ventral valve bears from eight to twelve ribs within the sinus, and from six to eight ribs in each of the lateral parts. In the latter the same tendency to become unsymmetrical, is exhibited, which is a remarkable character in *C. Purdoni*. In the dorsal valve the number of ribs amounts from twenty to thirty, of which always more than a third lie on the flatly rounded median fold. The ribs are highly rounded but not acute. Their augmentation is due to intercalation only. All the ribs remain undivided from the apical region to the front. No bifurcate ribs have been noticed in any of my specimens.

Similar traces of lateral expansions, as in *C. Purdoni* have been observed on the frontal and lateral margins of several specimens.

So far, as I have been able to make out the arrangement of the dental plates and septa, the internal structure is the same as in the preceding species. The figure Pl. XII, fig. 10, gives a lateral view of the ventral and dorsal septa, which agrees almost entirely with Waagen's figure of these characters in *C. Purdoni* (Pl. XXXII, fig. 6).

The measurements of my type specimen (fig. 5) are as follows:—

Entire length of the shell	45 mm.
Length of the dorsal valve	42 "
Entire breadth of the shell	52.5 "
Breadth of the median fold	29 "
Thickness of both valves	24 "
Apical angle of the ventral valve	107°
" " " " dorsal "	118°

Number of specimens examined.—25.

Remarks.—The specific claims of this form may perhaps be considered uncertain by some palæontologists, but the distinctions suggested in the preceding diagnosis are, in my opinion, of sufficient importance to allow it to be maintained as a separate species. Its remarkable size and the larger number of ribs constitute appreciable differences between the present species and *C. Purdoni*, although both are certainly very nearly related to each other.

By its unusually large dimensions this species recalls *C. Plicata*, Kutonga, from which it is, however, distinguished by the character of its ornamentation. In the Russian species the ribs are augmented by bifurcation, which is never the case in the Tibetan types.

3. CAMAROPHORIA SP. IND. AFF. *C. CRUMENA*, Mart. . Pl. XI, fig. 8.

A third species of the genus *Camarophoria* is represented among the material from Chitichun No. I by three specimens, attaining a length of 8 to 12 mm. only. The internal arrangement proves that they belong to the present genus. In their outlines and sculpture they recall *C. crumena*, Mart., and *C. pinguis*, Waagen. They differ from *C. purdoni*, in which the shell is almost entirely covered by ribs, even in quite young individuals (*vide* Pl. XII, fig. 8), by their ribs being restricted to the frontal portion of the shell and being acute on their tops. The number of ribs within the sinus varies from two to four.

As apparently no full grown specimens are among the Tibetan examples, I must leave it undecided, whether they should be attributed to one of the two above quoted forms, or to a separate species.

Suborder: ANCYLOPEGMATA, Zittel.

Family: *TEREBRATULIDÆ*, King.

Subfamily: *TEREBRATULINÆ* Waagen.

Subgenus: *DIELASMA*, King.

1. *DIELASMA BIPLEX*, Waagen. Pl. XI, figs. 6, 7, (?) fig. 5.

1882. *Dielasma biplex*, Waagen, Palæontologica Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 349, pl. XXV, figs. 3, 4, 5.

Among a small number of specimens, by which the subgenus *Dielasma* is represented in the Chitichun fauna, the two examples figured (figs. 6, 7) may, in my opinion, be safely identified with the present species. The rest I must leave undetermined. My reasons for doing so will be easily understood by any one who has had to deal with incomplete forms belonging to a genus, in which the specific distinctions have been based on very subordinate details alone. A species of so large an extension, as was *Dielasma sacculus*, Martin, as defined by Davidson, may be of little use for stratigraphical or for biological purposes, but it can scarcely be denied, that species of so narrowly restricted, as those which have been introduced by L. de Koninck in *Dielasma*, are likewise practically useless.

The two figured specimens exhibit the elongately pentagonal outline, which is peculiar to Waagen's specimen Pl. XXV, fig. 5, from the middle Productus limestone of Musakheyl. They are, however, somewhat variable in their general shape, the specimen fig. 6 being more strongly elongated and having its greatest transverse diameter shifted considerably nearer towards the frontal part. The most conspicuous character, which is especially well developed in the specimen fig. 7, is the presence of two converging folds in the dorsal, and of a straight mesial fold in the ventral valve. In my second specimen, which has been slightly deformed by pressure, these characters are less distinctly indicated.

The ventral valve is provided with a tolerably large and thick beak, which is pierced by a broad, oval foramen. The apex is slightly bent over but not appressed to the apex of the dorsal valve. The small deltidium is clearly visible in the specimen fig. 6. From both sides of the foramen indistinct ridges descend for a short distance to the lateral parts of the valve, bordering the broad false area, whose lower part is not, however, distinctly marked off from the remainder of the shell. The frontal line is distinctly biplicate and produced into two slightly bent up lappets, corresponding to the two folds of the dorsal valve. The obtusely rounded, low ridge originates in the middle of the length of the valve, and gradually increasing

in width, reaches down to the front line. It is bordered on both sides by low, rounded depressions.

The dorsal valve is much more strongly vaulted in the transverse than in the longitudinal direction. In the apical region two indistinct, rounded folds originate, which diverge towards the front line leaving a low, triangular depression between them. In the specimen fig. 6 the marginal slope of these folds is marked by a distinct bend in the transverse profile of the valve.

Of the internal structure the presence of strongly developed dental and septal plates has alone been determined.

The measurements of the specimen figured on Pl. XI, fig. 7, are as follows:—

Entire length of the shell	. . . . .	34 mm.
Length of the dorsal valve	. . . . .	30.5 "
Entire breadth of the shell	. . . . .	25 "
Thickness of both valves	. . . . .	16.5 "
Apical angle of the ventral valve	. . . . .	75°
" " " " dorsal "	. . . . .	105°

Number of specimens examined.—2.

Remarks.—It is only with great hesitation, that I refer the adolescent specimen Pl. XI, fig. 5, to the present species. In this specimen the peculiar characters of *Dielasma biplex* are not yet distinctly indicated.

In the Salt Range *D. biplex* is restricted to the middle Productus limestone. Waagen quotes it from the Virgal and Kálábagh beds, but not from the Katta beds of this division.

The specimens of *Dielasma* are too incomplete to state whether other species besides the present form, are represented among them.

Subgenus: HEMIPTYCHINA, Waagen.

The genus *Hemiptychina* has been introduced by Waagen for such species of *Terebratulina fimbriata*, in which distinct septal but no dental plates have been developed. Rothpletz (*Palæontographica*, XXXIX, 1886, p. 72) rejected Waagen's genus, which he considers to be merely a stage of development in different series of the genus *Terebratula*. Oehlert (in Fischer's *Manuel de Conchyliologie*, III, p. 1315) likewise classes *Hemiptychina* among the synonyms of *Terebratula*. Deslongchamps (1884) however elevated the species united by Waagen in his genus *Hemiptychina* at least to the rank of a distinct group (*a*) of *Terebratula*, and Geheimrath von Zittel in his recently published *Grundzüge der Palæontologie* (p. 275) advocates the retention of the name *Hemiptychina* as a subgeneric denomination. In the present memoir the latter view has been followed.

In the permocarboniferous fauna of Chitichun No. 1 the subgenus *Hemiptychina* is represented by three species, all of which are identical with Salt Range forms.

1. HEMIPTYCHINA HIMALAYENSIS, Davidson. Pl. XII, fig. 4.

1862. *Terebratula himalayensis*, Davidson, Quart. Journ. Geol. Soc. London, XVIII, p. 27, Pl. II, fig. 1.
 1863. *T. himalayensis*, Davidson, in L. de Koninck, Mémoire sur les fossils paléozoïques recueillis dans l'Inde, p. 32, Pl. IX, fig. 1.
 1878. *T. himalayensis*, Waagen. Rec. Geol. Surv. Ind., XI, p. 186.
 1882. *Hemiptychina himalayensis*, Waagen, Pal. Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 368, Pl. XXVI, figs. 6-10.

This species is represented in the collection from Chitichun No. I by two specimens, agreeing perfectly with the figures and descriptions given by Davidson and Waagen.

The specimens are strongly elongated, truncated at their front, and provided with ten or eleven short folds. The two valves are equally vaulted. The beak is pierced by an oval foramen. The sculpture of both valves is smooth up to within a few millimetres of the margins, where the short rounded ribs are developed. In my examples, which have been slightly deteriorated by weathering, only the four or five folds occupying the front, are distinctly visible.

The measurements of my larger specimen are as follows :—

Entire length of the shell	. . . . .	23 mm.
Length of the dorsal valve	. . . . .	18.5 "
Entire breadth of the shell	. . . . .	16 "
Thickness of both valves	. . . . .	14 "
Apical angle of the ventral valve	. . . . .	70°
„ „ „ „ dorsal	„	app. 110°

Number of specimens examined.—2.

Remarks.—The present species is very common in the middle and upper Productus limestones, but very rare both in the Katta beds and in the lower Productus limestone of the Salt Range. Mr. Hughes collected it in a white crinoidal limestone in the Central Himalayas near one of the passes leading from Milam into Hundes.

2. HEMIPTYCHINA SPARSPLICATA, Waagen. Pl. XII, figs. 1, 2.

1882. *Hemiptychina sparsiplicata*, Waagen, ser. xiii, Salt Range Fossils, Pal. Indica, I, Productus Limestone Fossils, p. 366, Pl. XXVII, figs. 4, 5, 6.
 1892. *Terebratula himalayensis* var. *sparsiplicata*, Rothpletz, Die Perm- Trias- und Juraformation auf Timor und Rotti, Palæontographica, XXXIX, p. 85, Pl. X, fig. 10.

This species, which is a little more numerous represented among the collections from Chitichun No. I is only distinguished from *Hemiptychina himalayensis* by the smaller number of its folds.

The two species are linked together, according to Waagen's own statement, by a number of transitional forms. Nevertheless Waagen "thought it expedient to note the typical form of *H. sparsiplicata* by a special name" by reason of its geological importance. To *H. sparsiplicata* a mere varietal rank has been attributed by Rothpletz. I deemed it preferable to follow Waagen's view, without overrating the geological importance of the two species, the number of which among my material is altogether too small to allow any conclusion in this respect.

In all the examples under description the number of folds is considerably smaller, than in the two figured types of *H. himalayensis*. The species is rather variable in its outlines. The specimen figured on Pl. XII, fig. 2, exhibits the roundish shape and the large apical angle, which, according to Waagen, chiefly characterize the typical form of *H. sparsiplicata*. Fig. 1, on the contrary, represents a specimen of unusually elongated outlines.

The measurements of a specimen, agreeing with the typical form of *H. sparsiplicata* (fig. 2) are as follows :—

Entire length of the shell	. . . . .	20 mm.
Length of the dorsal valve	. . . . .	17 "
Entire breadth of the shell	. . . . .	15.5 "
Thickness of both valves	. . . . .	12.5 "
Apical angle of the ventral valve	. . . . .	82°
" " " " dorsal "	. . . . .	114°

Number of specimens examined.—8.

Remarks.—The present species is abundant in the lower Productus limestone and in the Katta beds, but rare in the Virgal and Kálábagh beds of the Salt Range. From the permian rocks of Timor the species has been quoted by Rothpletz.

3. HEMIPTYCHINA INFLATA, Waagen. Pl. XII, fig. 3.

1892. *Hemiptychina inflata*, Waagen, *Palaeontologia Indica*, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 372, Pl. XXVII, figs. 7, 8, 9.

To this characteristic species I can attribute only a single specimen, which is distinguished from the other specimens of *Hemiptychina* by its large size, its strongly inflated valves, its globular outlines, and its distinctly developed plications, which extend across the larger portion of the shell to the front line.

My specimen has been considerably damaged by weathering. In the dorsal valve especially the sculpture has been almost entirely destroyed. But the considerable inflation of the shell and the character of the folds which in the ventral valve originate in the proximity of the apical region, make a distinction from the two preceding species an easy matter. There are about ten folds present, four of which occupy the frontal portion of the ventral valve. The absence of any dental plate in this valve does not allow the present specimen to be confounded with *Dielasmina plicata*, Waagen.

The measurements of this specimen are as follows :—

Entire length of the shell	. . . . .	25 mm.
Length of the dorsal valve	. . . . .	20 "
Entire breadth of the shell	. . . . .	19 "
Thickness of both valves	. . . . .	19 "
Apical angle of the ventral valve	. . . . .	app. 70°
" " " " dorsal "	. . . . .	app. 120°

Number of specimens examined.—1.

Remarks.—*Hemiptychina inflata* is quoted by Waagen from the Virgal and Kálábagh beds of the middle Productus limestone and from the lowest beds of the upper Productus limestone in the Salt Range.

Genus: NOTOTHYRIS, Waagen.

1. NOTOTHYRIS TRIPPLICATA, nov. sp.. Pl. XIII, figs. 1, 2.

It is only on the analogy of its external shape, that I place the present species in Waagen's genus *Notothyris*, as I have not been able to make out the internal characters, although I have sacrificed a good number of specimens for their investigation. Nevertheless the reference of this species to *Notothyris* is barely more doubtful than Waagen's identification of *Terebratula djoulfensis*, Abich, with one of his species of *Notothyris* from the Salt Range Productus limestone.

In their general shape and outlines *Notothyris* and *Hemiptychina* exhibit a remarkable similarity. According to Waagen's statement, however, there is in *Hemiptychina* always a certain tendency to form a slightly vaulted frontal line, whilst in *Notothyris*, on the contrary, the tendency prevails to bend the frontal line in the opposite direction. In my specimens a very distinct sinuation takes place in the frontal line, so much so, that the indentations corresponding to the folds of the frontal region are situated at a lower level than those of the lateral parts. This peculiar feature marks the present species as forming part of the genus *Notothyris*.

The general outline of the present species is elongately oval or indistinctly pentagonal. The two valves are of very unequal depth, the ventral valve being much more strongly inflated than the opposite one.

The ventral valve is strongly curved both in the longitudinal and transverse directions, but even more so transversely. Longitudinally the curvature is very equal, but transversely it is slightly flattened in the middle portion of the shell. The beak is moderately thick, prominent, but not strongly bent over. It is pierced by a small foramen just behind its apex. An indistinctly limited off false area extends for a short distance from both sides of the beak.

The most characteristic feature in this valve is its peculiar sculpture, which remarkably differs from the ornamentation in all the hitherto described species of *Notothyris*. The valve is smooth for about half its length from the beak. Then there appear two very strong, sharp folds, which extend down to the front and very distinctly separate the frontal portion of the valve from the lateral parts. In the rounded valley, which is enclosed by these two folds, a third median fold rises, which is, however, slightly inferior in strength. On each side of the frontal portion of the valve one or two short lateral folds are developed. The margin of the valve is distinctly sinuated in the frontal region, so that the indentations corresponding to the three folds of the frontal part are situated at a lower level than those of the lateral parts.

The three high and sharp frontal folds, of which the middle one is slightly less strongly marked, are a constant character in all the numerous specimens, which I have been able to examine.

A great many imbricating striæ of growth are crowded together in the proximity of the margins, whereas few only are developed in the middle portion of the valve.

The dorsal valve is rather flat and always remarkably less strongly vaulted than the ventral one. In the longitudinal direction it is, however, strongly deflected in the vicinity of the front, frequently imparting to the entire shell a slightly truncated shape. In this valve the folds are much shorter than in the opposite one, and three quarters of its entire surface remain almost perfectly smooth, except for the imbricating striæ of growth. Four comparatively strong folds are situated on the frontal part. The lateral folds are but indistinctly developed. They occur to the number of one or two on each side of the front.

The front margin is slightly prolonged, corresponding to the situation of the ventral valve.

Of the internal characters of this species nothing is known to me.

The measurements of one of my type specimens are as follows:—

Entire length of the shell	. . . . .	20	mm.
Length of the dorsal valve	. . . . .	17	„
Entire breadth of the shell	. . . . .	15	„
Thickness of both valves	. . . . .	15	„
Apical angle of the ventral valve	. . . . .	67°	
„ „ „ „ dorsal	„	105°	

Number of specimens examined.—28.

Remarks.—This species of *Notothyris* is easily distinguished from all the other congeneric forms by its peculiar, triplicate sculpture. Nor is any species of *Hemiptychina* known to me, to which it might advantageously be compared.

In my preliminary report, on the geological results of the Himálayan expedition to Johár, Hundés and Painkhánda in 1892, I have quoted *N. simplex*, Waagen, among the species of this genus, represented in the permocarboniferous fauna of Chitichun No. I. After a careful examination of the specimens in question, I prefer however to abandon this view, as these examples are too imperfectly preserved to allow any satisfactory determination.

2. NOTOTHYRIS CF. SUBVESICULARIS, Davidson.

1862. *Terebratula subvesicularis*, Davidson, Quart. Journ. Geol. Soc., XVIII, p. 27, Pl. II, fig. 4.

1863. *Terebratula subvesicularis*, Davidson, in L. de Koninck, Mémoire sur les fossiles paléozoïques recueillis dans l'Inde, p. 32, Pl. IX, fig. 4.

1882. *Notothyris subvesicularis*, Waagen, Palæontologia Indica, ser. xiii, Salt Range Fossils, I, Productus Limestone Fossils, p. 378, Pl. XXVIII, figs. 3, 4.

I am unfortunately unable to give an adequate figure of the Tibetan representatives of this species, the only two available specimens having been sacrificed in fruitless attempts to make out their internal structure. I must consequently abstain from giving a detailed description but shall confine myself to the statement, that among the permocarboniferous fauna of Chitichun No. I. a few examples have been noticed, which in their external characters entirely agreed with Davidson's

species. Prof. Waagen who examined my specimens, likewise declared them to be identical with *Notothyris subvesicularis*.

In the Salt Range this species is characteristic of the upper region of the middle Productus limestone (Virgal and Kálábagh beds). In the upper Productus limestone it is extremely rare. Outside the Punjab it has been mentioned by Waagen from a white crinoidal limestone, which was picked up by Mr. Hughes near one of the passes leading from Milam into Tibetan territory.

Class : BROYZOA.

Order : GYMNOLEMATA, Allm.

Suborder : CYCLOSTOMATA, Busk.

Family : *FENESTELLIDÆ*, King.

Genus : FENESTELLA, Lonsdale.

1. FENESTELLA SP. IND. . Pl. XIII, Fig. 3.

Among the material from Chitichun No. I a few small fragments of colonies may be safely attributed to this genus. All the rest of *Bryozoa* in the collection are too badly preserved to allow any diagnosis. Nor did I dare to attempt a specific determination of the figured specimen of a *Fenestella*, as of the two faces of the colony the non-poriferous is alone accessible to observation. I have entirely failed in preparing the poriferous side, which is not only firmly attached to the rock, but also completely destroyed by having been altered into crystallized calcite.

The largest fragment of a colony available for description is fan-shaped, without the presence of any marked axis. It recalls *F. virgosa*, Eichwald (*Lethæa Rossica* I, Pl. 23, fig. 9, p. 358), but the meshes of the network are a little larger. The branches are rather thin, of equal thickness for their whole extent, and bifurcate in a somewhat irregular manner. Otherwise they run tolerably parallel to each other.

The fenestrules are oval or rectangular, with rounded off corners, and considerably longer than broad. There are about three fenestrules within the space of 5 mm. in the direction of the extension of the branches, and four in the transverse direction. The branches and the dissepiments are of nearly equal thickness.

The presence of an indistinct longitudinal striation of the branches cannot be positively asserted, as the surface in all the specimens appears to have been slightly injured by weathering.

Number of specimens examined.—4.

ECHINODERMATA.

Class : CRINOIDEA.

In the permocarboniferous fauna of Chitichun No. I only stem joints of representatives of this class have been preserved. Although very abundant, they are insufficient for generic determination. I must consequently abstain from giving descriptions or figures, and merely record their presence in the Chitichun limestone.

CŒLEENTERATA.

Class : SPONGIÆ.

Subclass : CALCISPONGIÆ.

Order : SYCONES, Hæckel.

Suborder : SPHINCTOZOA, Steinmann.

Family : *SPHÆROSIPHONIDÆ*, Steinmann.Genus : *AMBLYSIPHONELLA*, Steinmann.

In placing *Amblysiphonella* among the *Sycones*, I am following the view of Rauff. (Palæospongiologie, I. Theil, Palæontographica, XL, 1893, p. 102), who does not share the opinion expressed by Steinmann (*Pharetronen-Studien*, Neues Jahrbuch, 1882, II. Th., p. 169) and Waagen, regarding the systematic position of this genus among the *Pharetrones*.

I regard a specimen, which, notwithstanding its rather fragmentary state of preservation, appears to be nearly related to *A. vesiculosa*, de Kon., but differs by its comparatively smaller size, as a typical representative of the genus.

1. *AMBLYSIPHONELLA*, *AFF. VESICULOSA*, de Koninck. Pl. XIII, Fig. 4.

The fragment available for description consists of five segments, of which only the lower three are tolerably perfect. The segments are shortly cylindrical with convex sides, and separated from each other by deep furrows. The outer walls of the segments are thin and perforated all over by numerous, very small pores.

Both longitudinal and transverse sections exhibit a moderately wide central tube, bordered by a rather thick wall. It is surrounded by the circular chambers, corresponding to the segments, in the shape of broad rings.

I have not succeeded in making out the details of the internal structure although the presence of numerous vesicles within the chambers has been noticed.

The measurements of this fragment are as follows :—

Entire length of the fragment	. . . . .	25 mm.
Diameter of the third segment	. . . . .	135 "
" " " lowest "	. . . . .	12 "
Height of the third segment	. . . . .	5 "
Width of the central tube	. . . . .	3·5—5 "

Number of specimens examined.—1.

Remarks.—This fragment is rather nearly allied to *Amblysiphonella vesiculosa*, de Koninck (Waagen, Pal. Indica, ser. xiii, I, p. 973, Pl. CXXII, fig. 1), from which it differs by its considerably smaller size. In this respect it agrees with *A. Barroisi*, Steinmann (Neues Jahrbuch, 1882, II. Th., p. 169, Pl. VI, fig. 1) from the carboniferous rocks of Sebargas in Spain. From the latter species it is however readily distinguished by its cylindrical shape, the angle of emergence being considerably smaller than in *A. Barroisi*.

Class: ANTHOZOA.

Order: TETRACORALLIA, Hæckel.

Family: *CYATHOPHYLLIDÆ*, Hæckel.

Genus: LONSDALEIA, M'Coy.

1. LONSDALEIA INDICA, Waagen and Wentzel. Pl. XIII, figs. 5, 6.

1886. *Lonsdaleia indica*, Waagen and Wentzel, Palæontologia Indica, ser. xiii, Salt Range Fossils, I. Productus Limestone Fossils, p. 897, Pl. CI, figs. 1—3, Pl. CXV, figs. 3-4.

This is by far the commonest species of coral in the Chitichun limestone. Part of the south-eastern slope of the crag of Chitichun No. I is made up almost entirely of a coral rock, composed of corallites, which in every respect agree with *Lonsdaleia indica* from the Salt Range Productus limestone.

The compound corallum is composed of cylindrical, tolerably straight corallites which are rather far apart and are only in very few cases blended together. Their surface is covered with numerous transverse wrinkles, and exhibits a delicate longitudinal striation. The diameter of the calices varies from 3 to 7 mm. No traces of a secondary wall are indicated. The columella occupies nearly a third of the diameter of the entire calix. There are about twenty primary septa, and an equal number of secondary ones.

In transverse thin sections (Pl. XIII, fig. 6c) the transverse lamella, which

forms the centre of the columella, is very distinctly exhibited. This character makes a distinction of *L. indica* and *L. virgalensis*, Waagen and Wentzel (loc. cit. p. 900, Pl. CXVI, fig. 2 ; Pl. CI, fig. 4) from all the congeneric species an easy matter. It is the presence of this central transverse lamella, and the exceptional arrangement of the tabulæ, which in Waagen's opinion, might even be considered sufficient for the introduction of a distinct generic denomination for *L. indica* and its allies.

From the central transverse lamella radiating lamellæ originate, which are crossed by a concentric lamellation. The columella is marked off very sharply from the remainder of the calyx by a distinct wall. This wall is reached by the majority of the primary septa. A few of the latter are even brought into contact with one of the radiating lamellæ within the columella. The interseptal dissepiments are very numerous, but are not arranged regularly so as to form concentric accessory walls.

Remarks.—I think there can be scarcely any doubt of the identity of the specimens from the Chitichun limestone with *Lonsdaleia indica*. The larger diameter of the branches and the irregular arrangement of the interseptal dissepiments forbid an identification with *L. virgalensis*, which is, however, very nearly allied to *L. indica* and is only distinguishable by very subordinate characters. I know of no other species of the genus *Lonsdaleia*, with which my specimens could be advantageously compared.

In the Salt Range *L. indica* occurs in very large numbers in the coral beds of the middle Productus limestone (Virgal beds), but extends also, though more rarely, into the Kálábagh beds and Khundghát beds. It has neither been found in the Amb beds nor in the Katta beds.

Family : *ZAPHERENTIDÆ*, Hæckel.

Genus : *AMPLEXUS*, Sowerby.

1. *AMPLEXUS*, SP. IND. AFF. *ABICHI*, Waag. and Wentzel. Pl. XIII, fig. 7.

Among the corals from Chitichun No. I there are a few specimens belonging to this genus, but their state of preservation is unsatisfactory, and the matrix so spathic that their structure cannot be made out well enough to permit of specific determination. I must consequently while drawing attention to their remarkable similarity to *A. Abichi*, Waagen and Wentzel (Pal. Indica, ser. xiii, I, p. 903) abstain from any identification with previously described species of *Amplexus*.

The corallum is simple, subcylindrical, straight or slightly curved, and provided with strongly prominent, rounded or imbricating wrinkles of growth, completely encircling the corallum. The epitheca is comparatively thin and covered with very numerous and delicate longitudinal striæ. The outer walls of the septa

show through the epitheca in the shape of thin, straight lamellæ. To a diameter of 14 mm. of the corallum 24 septa correspond. They are short, but their exact length cannot be made out in consequence of the spathic character of the matrix. The tabulæ are flatly curved. The shape of the calix is unknown to me.

The species, to which the present one seems to be most nearly related, are *Amplexus Abichi* (*A. coralloides*, Abich., Geologische Forschungen in den Kaukasischen Ländern, I. Th. Eine Bergkalkfauna aus der Araxes-Enge bei Djoulfa, p. 87, Pl. XI, fig. 10) and *A. coralloides*, Sowerby. The similarity with other congeneric species, described by L. de Koninck in his monograph of the carboniferous fossils of Belgium and by Stuckenberg in his memoir on the corals and bryozoa of the carboniferous rocks of the Ural and Timan (Mém. Com. Géol. Russ., St Pétersbourg, 1895, X, No. 3.) is less close. I do however not venture to identify my specimens any of the two above quoted species, as my insufficient knowledge of their internal characters forbids an exact determination.

PROBLEMATICA: Gen. et sp. ind. . Pl. XII, fig. 8.

Among the material from Chitichun No. I there is a very strange fossil, whose determination has puzzled me for a long time. I have tried in vain to make out to which class of invertebrates it might belong. Nor have any of my learned friends, who examined this curious fossil, arrived at a more satisfactory conclusion. Perhaps its true character will be revealed by the discovery of more complete specimens. I, therefore, give its description and figure, notwithstanding the impossibility of ascertaining its zoological position.

The specimen in question consists of a system of root-like appendages, uniting with a central ring-shaped body. The root-shaped appendages, which occur to the number of five, exhibit a semicircular arrangement and are fastened both to the central main-body and to each other. By reason of their semicircular shape, however, they touch each other for a short distance only, and afterwards strongly diverge. Triangular spaces are left between the places, where two neighbouring appendages are attached to the body and to each other. The appendages terminate in sharp points. The largest diameter is about 5 mm. The diameter of the central, ring-shaped body attains nearly the same size. The largest diameter of the slightly elliptical inner portion, encircled by this body, is about 16 mm.

The internal structure of the fossil is very peculiar. Both the main body and the appendages are divided by deep transverse furrows into numerous segments of irregular size. These furrows correspond in the ring-shaped body and in the appendages, and unite in the places where the latter are fastened to each other. To these deep furrows a very large number of delicate transverse furrows is added, which are more distinctly preserved near the outer margin of the fossil and thus at a superficial glance give the impression of a proper marginal zone, distinguished by their presence. This is, however, not the case, but the delicate transverse furrows are

seen to continue throughout the entire thickness of the appendages and main body wherever the latter are fairly preserved.

I first thought that this strange fossil might belong to the *Calcispongiae*, and ought perhaps to be placed in the relationship of *Amblysiphonella radicifera*, Waagen and Wentzel (Pal. Indica, ser. xiii, I, Pl. CXXIII., CXXIV, fig. 1. p. 975). This was also Prof. Waagen's view when he first examined the specimen. Geheimrath von Zittel, however, one of our most competent authorities on this subject, after a close examination of the Tibetan fossil refused to acknowledge the possibility of its belonging to the *Calcispongia*, and suggested a similarity, though rather distant, to crinoid roots. The fact of the specimen being unique forbade the use of the grindstone. I could therefore only prepare a single section of its outlying portions for microscopical examination, but this section revealed nothing of the characteristic structure of *Echinodermata*, although this structure may only have been destroyed by the process of fossilisation.

The fossil in question must consequently still be treated as a problematicum.

STRATIGRAPHICAL RESULTS.

The fauna of the limestone crag of Chitichun No. I is composed of the following species:—

CRUSTACEA.

1. *Phillipsia Middlemissi*, Diener.
2. *Cheiropyge himalayensis*, Diener.

CEPHALOPODA.

3. *Stacheoceras Trimurti*, Diener.

LAMELLIBRANCHIATA.

4. *Aviculopecten aff. jabiensi*, Waagen.

BRACHIOPODA.

5. *Productus lineatus*, Waag.
6. „ *Cora*, d'Orb.
7. „ *semireticulatus*, Mart.
8. „ *boliviensis* var. *Chitichunensis*, Diener.
9. „ *cf. subcostatus*, Waag.
10. „ *gratiosus*, Waag.
11. „ *cancriniformis*, Tschernyschew.
12. „ *Abichi*, Waag.
13. „ *mongolicus*, Diener.
14. *Marginifera typica*, Waag.
15. *Aulosteges tibeticus*, Diener.
16. *Lyttonia nobilis*, Waag.
17. *Spiriferina octoplicata*, Sow.

HIMALAYAN FOSSILS.

18. *Spirifer musakheylensis*, Davidson.
19. „ *Wynnei*, Waag.
20. „ *tibetanus*, Diener.
21. *Martinia cf. glabra*, Mart.
22. „ *elegans*, Diener.
23. „ *nucula*, Rothpletz.
24. „ *semitlana*, Waag.
25. „ *acutomarginalis*, Diener.
26. „ *contracta*, Meek and Worthen.
27. *Reticularia lineata*, Mart.
28. *Athyris (Spirigera) Royssii*, Lév.
29. „ „ *capillata*, Waag.
30. „ „ *subexpansa*, Waag.
31. *Spirigerella Derbyi*, Waag.
32. „ *grandis*, Waag.
33. „ *pertumida*, Diener.
34. *Enteleles Tschernyscheffi*, Diener.
35. *Uncinulus timorensis*, Beyrich.
36. *Camarophoria Purdoni*, Dav.
37. „ *gigantea*, Diener.
38. „ *aff. crumena*, Mart.
39. *Hemiptychina himalayensis*, Dav.
40. „ *sparsiplicata*, Waag.
41. „ *inflata*, Waag.
42. *Dielasma bipes*, Waag.
43. *Notothyris triplicata*, Diener.
44. „ *cf. subvesicularis*, Dav.

BRYOZOA.

45. *Penestella*, sp. ind.

SPONGIÆ.

46. *Amblysiphonella, aff. vesiculosa*, Kon.

ANTHOZOA.

47. *Amplexus p. ind. aff. A. Abichi*, Waag. and Wentzel.
48. *Lonsdaleia indica*, Waagen and Wentzel.

Altogether 48 species, among which the *Brachiopoda* numbering 40 species by far predominate, both in species and individuals, and comprise five-sixths of the entire fauna.

I ought now to enter into a discussion of the relations which exist between the fauna of the Chitichun limestone and the faunas of homotaxial beds in other countries. As however for a comparison of these faunas among each other the determination of the upper limit of the carboniferous system is of fundamental importance, I shall defer such a discussion till the present state of the so-called permocarboniferous problem has been explained. This will be found the more necessary,

as some very important memoirs have thrown new light on the subject since the geological results of Waagen's monograph of the *Productus* limestone fossils were published, in consequence of which the views of this author regarding the correlation of the permocarboniferous strata will have to be partly modified.

The difficulty of correlating the series of strata intermediate between the typical carboniferous and permian deposits chiefly consists in the fact that an uninterrupted sequence of marine beds of both systems was for a long time unknown. In Europe the discovery of this sequence is due to the united efforts of the Russian geologists, whose works have made Central Russia and the Ural Mountains a classic ground for the study of the marine development of upper carboniferous and permocarboniferous beds.

In Central Russia the upper carboniferous series is divided into two well defined groups. The lower or Moscovian stage (horizon of *Spirifer mosquensis*) contains the fauna of Mjatchkowa, described by Trautschold; the upper or Gshelian stage (horizon of *Chonetes uralica*, "ouralien") contains the fauna of Gshel, which has been studied by Nikitin. In the upper carboniferous rocks of the Ural Mountains two faunistically different horizons may, according to Tschernyschew, be likewise distinguished: a lower stage (C₂) with *Spirifer cf. mosquensis*, and an upper one (C₃ horizon of *Productus Cora*) which in itself is rather manifold but consists chiefly of *Fusulina* limestones. The topmost limestones (Schwagerina horizon) must be placed on a somewhat higher level than the Gshelian stage, corresponding to the Schwagerina dolomites of the Oka-Kljasma and Oka-Wolga-basins, which have been proved by Sibirzew¹ to overlie the horizon of *Chonetes uralica* (Nikitin's Gshelian stage). The Artinskian marls and sandstones conformably overlie the carboniferous rocks. There is no break in the sequence, as has been proved by Tschernyschew and Krassnopolssky in a most convincing manner.

To the Artinskian sandstones and marls (CPg) and to the following limestone-dolomite horizon (CPe) the name permocarboniferous has been applied by Russian geologists. It is in this sense only that the term "permocarboniferous" will be used in this memoir, as it is the only one which does not inevitably lead to misunderstanding. The denomination Artinskian, which has been proposed by Munier-Chalmas and A. de Lapparent² may perhaps be preferable, as it excludes all misunderstandings, but the term permocarboniferous in the meaning of the Russian geologists has been accepted lately by so many authors (*e.g.*, Waagen, Credner, Kayser, Oldham) that I should not like to drop it altogether.

It is only above these permocarboniferous strata, *viz.*, above the Artinskian sandstones and marls and the limestone-dolomite horizon, that the true "Permian" as it had been understood by Sir Roderick Murchison, follows.

Karpinsky³ and Tschernyschew,⁴ two authors, to whom the most detailed studies

¹ *N. Sibirzew*,—Mém. Com. Géol. Russ. St. Pétersbourg, 1896, XV, No. 2, pp. 227—247.

² *Munier-Chalmas et A. de Lapparent*,—Note sur la nomenclature des terrains sédimentaires, Bull. Soc. Geol. France, sér. iii, XXI, 1893, p. 752.

³ *A. Karpinsky*,—Ueber die Ammonoiten der Artinsk-stufe, Mem. Acad. Imp. Sci. St. Petersburg, sér. xxxvii, p. 86—101.

⁴ Mém. Com. Géol. Russ. St. Pétersbourg, III, No. 4, 1889, pp. 362—366.

of the Artinskian fauna are due, strongly advocate the distinction of the permocarboniferous from carboniferous and permian systems, and are decidedly averse to uniting it with either the one or the other. Tschernyschew especially strongly combats the view of the majority of geologists who proposed to unite the permocarboniferous with the permian, as a lower division of the system. According to him a separation of the permocarboniferous from the permian system is demanded by the general aspect of the fauna, in which the carboniferous types greatly predominate, chiefly among the brachiopoda. If it ought to be united either with the carboniferous or permian system, in spite of its distinctly intermediate position, it must necessarily be placed in the former, on the strength both of the carboniferous character of its fauna and of historical priority, since the Artinskian sandstone had been correlated with the carboniferous millstone-grit of Western Europe by Sir Roderick Murchison, who first introduced the name of permian.

Against the first argument the objection may be raised that notwithstanding the prevalence of carboniferous types in the Artinskian fauna, the latter "marks a very important moment in the history of development of organic remains, namely, the first appearance of true ammonites with complicated sutures."¹ Nor is the large percentage of carboniferous types in the Artinskian fauna an astonishing fact, in view of the absence of any break in the sequence of marine beds from the upper carboniferous to the true permian strata. Even in beds, which must be placed very high in the permian system, in the upper *Productus* limestones of the Salt Range and in the *Otoceras* beds of Julfa, the fauna contains a proportionately large number of carboniferous forms. It is to the faunas of these deposits, the normal representatives of the pelagic permian, not to the local fauna of the Zechstein, that the permocarboniferous fauna must be compared, if we want to get a clear idea of its relationship to those of the upper carboniferous and permian. Bearing in mind the gradual passage from an upper carboniferous to a permian fauna through the intermediate group of rocks, the question to be answered is, which consideration is of the greater importance in defining the boundary between the two systems, the appearance of a new group of cephalopoda, which become of an unparalleled stratigraphical value in mesozoic times, or the presence of a belated fauna, composed of forms which are generally not well adapted for the characterisation of narrowly limited horizons.

The majority of geologists have decided in favour of the first alternative. Gümbel,² Krassnopolssky,³ Kayser,⁴ Waagen,⁵ Credner,⁶ Munier-Chalmas and A. de Lapparent, Frech—to enumerate only a small number among them,—are unanimous in regarding the permocarboniferous as the lowest division of the permian system.

A discussion of the permocarboniferous problem from a historical point of view

¹ *A. Karpinsky*,—loc. cit. p. 101.

² *C. W. Gümbel*,—*Geologie von Bayern*, Kassel 1888, I. Th. p. 634.

³ *A. Krassnopolssky*,—*Mém. Com. Geol. Russ. St. Pétersbourg*, XI, No. 1, p. 506.

⁴ *E. Kayser*,—*Lehrbuch der geologischen Formationskunde*, Stuttgart, 1891, p. 157.

⁵ *W. Waagen*,—*Pal. Indica*, ser. xiii, Salt Range Fossils, IV, Geological Results, p. 238.

⁶ *H. Credner*,—*Elemente der Geologie*, 7. Aufl., Leipzig, 1891, 503.

leads to a similar result. This side of the question has been especially treated by Frech,¹ whose reasoning I consider to be entirely justified.

Sir Roderic Murchison, it is true, did not include the Artinskian deposits in his permian system, but on the other hand, his correlation of these deposits with the carboniferous millstone-grit is decidedly erroneous, and its priority cannot be respected. In the Rhenish regions, where the sequence of terrestrial and lacustrine, plant-bearing strata of this epoch is most complete, the true coal measures come to an end with the Ottweiler Schichten, whereas the following series of rocks comprising the Cuseler and Lebacher Schichten, have been united in a lower division of the permian system by Gümbel. In the Carnian Alps plant-bearing beds, containing a rich flora of the Ottweiler Schichten² alternate with Fusulina limestones, which have been proved by Schellwien³ to be homotaxial with Nikitin's Gshelian stage in Central Russia. As has been noticed by Geyer,⁴ this alternating series of dark Fusulina limestones and plant bearing beds is conformably followed by a compact mass of white Fusulina limestones (Troglkofelkalk) containing *Spirifer supramosquensis*, Nikitin, which must be correlated with the topmost carboniferous Fusulina limestones (Schwagerina horizon) of the Ural Mountains. The homotaxis of the Ottweiler Schichten and of the Carnian Fusulina limestone, which itself corresponds in age to the uppermost carboniferous beds of Central Russia (Gshelian stage) and of the Ural (Cora horizon, and Schwagerina horizon), apparently requires the boundary line between the two systems to be drawn immediately above the Schwagerina limestone of the Ural and Timan, and below the Artinskian stage.

A particular view of the permocarboniferous problem has been taken by Rothpletz⁵ who hints at the probability, "that the permocarboniferous may not represent a distinct stratigraphical stage, but merely a particular facies, which is entirely wanting in Western Europe, was confined to the commencement of the permian epoch in Russia, but lasted throughout the whole of this epoch in some parts of Asia and North America."

I quite agree with Rothpletz in his statement that the normal sediments of the ocean, which covered parts of North-Western India, of Central Asia and of Russia, in the commencement of the permian epoch (Artinskian stage) must for the later stages of this epoch be looked for in the upper Productus limestone of the Salt Range and not in the Zechstein nor in Murchison's "permian system" of Russia, but I cannot understand why this view should be inconsistent with the character of the Artinskian deposits as a distinct stratigraphical horizon. A correlation of the permocarboniferous horizon proper with higher stages of the permian system cannot be

¹ *F. Frech*.—Die Karnischen Alpen, Halle, 1894, p. 367.

² *E. Suess*.—Das Antlitz der Erde II, Bd., p. 304; *E. Schellwien*, Die Fauna des Karnischen Fusulinen kalks, I. Th, Palæontographica XXXIX, 1892, p. 1; *F. Frech*, Die Karnischen Alpen, Halle, 1894, pp. 309-328.

³ *E. Schellwien*.—Zeitschr. Deutsch. Geol. Ges., 1894, p. 70.

⁴ *G. Geyer*.—Ueber die Geologischen Verhältnisse im Pontafeler Abschnitt der Karnischen Alpen, Jahrb. K. K. Geol. Reichs-Anstalt, 1896, 46, Bd., p. 156.

⁵ *A. Rothpletz*, Die Perm Trias und Jura-formation auf Timor und Rotti Palæontographica, XXXIX, 1892, p. 66.

admitted, seeing the difference of their cephalopod faunæ. Ammonites with ceratitic sutures are absent in the Artinskian stage. Their presence is barely less characteristic of the younger horizons of the permian system, than the first appearance of more highly developed *Ammonoidea*, is characteristic of the permocarboniferous stage. Rock-specimens like the one described by E. v. Mojsisovics (Denkschr. K. Akad. Wiss. Wien, math nat. Cl., LXI, 1894, p. 458) from Stoliczka's collections near Woábjlga (Karakorum Pass), in which ammonites with goniatitic, ceratitic and ammonitic sutures are mixed together, have up to now never been found in strata geologically older than the pelagic permian of India or Julfa.

In Russia the marine deposits of the Artinskian stage are overlaid by Murchison's "permian system," a sequence of brackish, freshwater and marine sediments, with an impoverished fauna,¹ which cannot be considered as the normal sediments of the permian epoch. This remark applies equally to the local development of the German Zechstein or of the British magnesian limestone. The pelagic equivalents of these deposits must be looked for in the permian rocks of the Mediterranean region in South-eastern Tyrol, Sicily and Armenia, of the Pamirs, of India and the Malayan Archipelago, of North America and probably also of Spitzbergen and the neighbouring islands. These sediments are proved both by their pelagic faunas and by their wide distribution within the Jhetys² and the Arctic-Pacific region to be the deposits of the great permian oceans and consequently the *normal* sediments of the permian epoch.

In the Mediterranean region three different rock groups have yielded fossil remains of this pelagic development of the permian epoch. These rock groups are the Fusulina limestones of the valley of Sosio in Sicily, the Bellerophon limestone of South-eastern Tyrol and Friaul, and the Otoceras beds of Julfa in Armenia. All of them are of a rather isolated occurrence and, as far as one may judge from their faunas, of different age.

The lowest position is apparently held by the Fusulina limestone of Sicily. Its cephalopod fauna seems to be more nearly related to the Artinskian one than to those of the Jabi beds of the Salt Range or of the Otoceras beds of Julfa. Ammonites with ceratitic sutures are yet absent. According to Karpinsky's statement, one species of *Medlicottia* is identical with an Artinskian form, ten more species are very nearly allied. On the other hand Karpinsky and Waagen noticed the first appearance of *Waagenoceras* and *Hyattoceras* in Sicily, two genera, which show a much more complicated sutural line than any of the Artinskian *Ammonea*. Waagen consequently places the Fusulina limestone of Sicily on a higher level than the permocarboniferous stage, but on slightly lower level than the Jabi beds of the upper Productus limestone. A more exact comparison of the Sicilian and Salt Range faunas will only be possible after the publication of Gemmellaro's monograph of the *Brachiopoda* from the Sosio limestone, as no cephalopod fauna is known in the Salt Range below the Jabi beds.

¹ *W. Amalitzky*—The permian system in the Oka-Wolga basin, 1887; *N. Sibirzew*, Mém. Com. Géol. Russ. St. Pétersbourg, XV, No. 2, pp. 247—265.

² *E. Suess*—Natural Science, Vol. II, No. 13, March 1893.

The *Otoceras* beds of Julfa with their strongly marked triassic affinities must certainly be higher in the upper palæozoic series than the *Fusulina* limestone of Sosio. They cannot be much different in age from the *Otoceras* beds of the Himálayas, although the latter certainly hold a somewhat higher stratigraphical position, and they may consequently be placed on a level with the upper *Productus* limestone or with the *Chidru* group of the Salt Range.

The youngest of the three rock groups is probably the *Bellerophon* limestone of South-eastern Tyrol. Its fauna is a very peculiar one, species identical with those known outside this rock group being almost completely absent. The predominance of palæozoic types induced Stache¹ to fix the homotaxis of these beds as upper permian, whereas Gumbel supposed them to be of lowest triassic age. I have quite recently succeeded in discovering an interesting fauna of these beds in the valley of Sexten, containing the first ammonites and *Orthocerata* hitherto known in this horizon, which are rather in favour of Stache's view.

In none of these three permian rock groups of the Mediterranean region is a normal sequence of marine beds exposed, with the possible exception of the *Bellerophon* limestone of the Carnian Alps, which, however, is underlaid by an enormous mass of unfossiliferous limestones and dolomites. Their correlation must consequently be based on palæontological evidence alone.

The second region, in which a gradual transition of marine beds of the carboniferous and permian systems has been observed, is the central and south eastern portions of the United States of North America. In the typical sections of Kansas and Nebraska a gradual passage from the upper coal measures to the higher beds, with a fauna of a permian aspect, has been noticed, but the question, where the boundary between the two systems ought to be drawn, still remains to be settled. A very able paper by H. S. Williams,² in which the present state of the permo-carboniferous problem in America is exposed, has demonstrated that this question is still an open one. "In the first place the formations themselves are not delimited on the same basis in different provinces, and secondly the fossils have been reported under so many different names, that a thorough revision of the several biologic groups is necessary, before the various lists prepared can be scientifically correlated."

A cephalopod fauna of a permian type has been described by C. White³ from the Baylor and Archer counties in Western Texas. Of the five species of ammonites composing this fauna, *Medlicottia Copei*, *Hyaleloceras Cumminsi*, and *Popanoceras Walcottii* are very nearly allied to Sicilian forms, whereas *Popanoceras Parkeri*, Heilprin,⁴ and *Paralegoceras baylorense*⁵ exhibit a near relationship to Artinskian species.

¹ G. Stache,—Beiträge zur Fauna der Bellerophonkalke Südtirols, Jahrb. K. K. Geol. Reichs-Anst., Wien 1877, XXVII. pp. 271-318; 1878, XXVIII, pp. 93-168.

² Correlation Papers, Devonian and Carboniferous, Bull. U. S. Geol. Survey, Washington, 1891, No. 80. pp. 193-212.

³ C. White,—The Texan Permian and its mesozic types of fossils, Bull. U. S. Geol. Surv., Washington, 1891, No. 77.

⁴ Proc. Acad. Nat. Sciences, Philadelphia, 1887, VXXXVI pp. 53-55.

⁵ *Goniatites Baylorensis*, White. From its general shape and to the character of the sutural line this form probably belongs to Hyatt's genus *Paralegoceras*.

A third region, distinguished by an uninterrupted sequence of marine beds reaching from upper carboniferous strata through the permian system, is the Salt Range in the Punjab.

This sequence begins with the Amb beds or lower *Productus* limestone. The stratigraphical relations of the Amb beds to the glacial boulder beds and to the *Eurydesma* sandstones with their Australian affinities are yet doubtful, as has been stated by Noetling in a recent paper on this subject.¹ The *Productus* limestones however are quite conformable to each other, and it is only between their top-most beds (Chidru group) and the next overlying lower Ceratite limestones, that a break in the sequence has been suggested by Waagen.

The following classification of the *Productus* limestone series has been adopted by Waagen:—

Upper <i>Productus</i> Limestone.	{	Chidru beds. Jabi beds. Khund Ghat beds.
Middle <i>Productus</i> Limestone	{	Kalabagh beds. Virgal beds. Katta beds.
Lower <i>Productus</i> Limestone.		Amb beds.

This classification has been slightly modified by R. D. Oldham,² who proposed a separation of the Chidru group from the rest of the series and a separation of the Katta beds from the middle *Productus* limestone. I did not however think it advisable to follow Oldham's second proposal, as the different meaning of the terms "lower" and "middle" *Productus* limestone in two memoirs of the *Palæontologia Indica* would be confusing. I consequently deemed it preferable to accept Waagen's classification, but to unite the Virgal and Kalabagh beds into an upper division of the middle *Productus* limestone, thus marking the faunistic contrast between this rock group and the underlying Katta beds.

There can be no doubt as to the permian age of the Chidru group with its peculiar bivalve fauna, and of the upper *Productus* limestone. The homotaxis of the lower divisions of the *Productus* limestone series is however uncertain, and some difference of opinion exists regarding the correlation with upper palæozoic strata outside India.

Waagen believed the entire *Productus* limestone series to be permian. He correlated the lower *Productus* limestone and the Katta beds with the Artinskian stage of Russia, considering them as permocarboniferous. To this correlation he was chiefly led by the supposition of a stratigraphical break between the upper carboniferous and permocarboniferous beds of the Ural Mountains, filled up, as he believed, in the Salt Range by the glacial boulder bed and by the *Eurydesma* sandstones. This view has become untenable, since in the Ural and Timan the con-

¹ *F. Noetling*, Beiträge zur Kenntniss der Glacialen Schichten permischen Alters in der Salt Range, Neues Jahrbuch, 1896, Bd. II, pp. 61—86.

² *A Manual of the Geology of India*, 2nd edition, by *R. D. Oldham*, Calcutta, 1893, pp. 122, 123.

tinuity of the sequence of marine beds from the horizon of *Productus giganteus* (mountain limestone of Western Europe) to the Artinskian stage has been proved by the geologists of the Russian survey in a most convincing manner. On the other hand, the recent memoirs of Nikitin, Schellwien, Tschernyschew, Suess, and Sibirzew tend to show that the number of carboniferous types in the Productus limestone is considerably larger than had been anticipated by Waagen.

The species from the Productus limestone, identical with those of upper carboniferous strata in other countries, are the following :—

<i>Productus Cora</i> , d'Orb.	<i>Spirifer alatus</i> , Schloth.
„ <i>lineatus</i> , Waag.	<i>Reticularia lineata</i> , Mart.
„ <i>semireticulatus</i> , Mart.	<i>Martinia glabra</i> , Mart.
„ <i>indicus</i> , Waag.	„ <i>semitrana</i> , Waag.
„ <i>opuntia</i> , Waag.	<i>Spiriferina octoplicata</i> , Sow.
„ <i>spiralis</i> , Waag.	„ <i>ornata</i> , Waag.
<i>Orthothetes semiplanus</i> , Waag.	<i>Athyris Roysii</i> , Lev.
<i>Orthis Pecosii</i> , Marcou.	<i>Retzia (Eumetria) grandicosta</i> , Waag.
<i>Derbya grandis</i> , Waag.	<i>Camarophoria Purdoni</i> , Dav.
<i>Enteletes Kayseri</i> , Waag.	<i>Richthofenia sinensis</i> , Waag.
<i>Spirifer musakheylensis</i> , Dav.	<i>Fusulina longissima</i> , Möll.
„ <i>striatus</i> , Mart.	<i>Stenopora ovata</i> , Lonsd.
„ <i>Marcoui</i> , Waag.	<i>Fenestella perelegans</i> , Meek.

To these 26 species the following nine may be added as doubtful ones:—

<i>Productus gratiosus</i> , Waag.	<i>Athyris pectinifera</i> , Sow.
„ <i>Humboldti</i> , d'Orb.	<i>Dielasma elongatum</i> , Schloth.
<i>Streptorhynchus pelargonatus</i> , Schloth.	<i>Lyttonia Richthofeni</i> , Kayser.
<i>Orthis indica</i> , Waag.	<i>Orthoceras cyclophorum</i> , Waag.
	<i>Aviculopecten derajatensis</i> , Waag.

In all 35 species. It only needs a comparison of this list with that given by Waagen on p. 163 of his “Geological Results” (Palæontologia Indica, ser. xiii, Vol. IV) to prove the carboniferous affinities to be much more strongly marked in the Salt Range Productus limestone, than could be anticipated by this learned author.

The affinity of the fauna of the lower Productus limestone to those of the Gshelian stage of Russia, of the Cora and Schwagerina horizons of the Ural Mountains and of the Carnian Fusulina limestone induced Rothpletz (loc. cit. p. 63), Oldham (loc. cit. p. 125) and Frech (loc. cit. p. 372) to correlate the lower Productus limestone with upper carboniferous rather than with permocarboniferous beds. E. Suess,¹ after a careful examination of the upper carboniferous fauna of Tongitar (southern slopes of Tian-shan) likewise agrees with the above mentioned authors in the opinion, “that the entire Productus limestone forms a series, which cannot be separated from the carboniferous system, and that the *Fusulina* bearing Amb beds certainly belong to the latter, although their correlation with the Gshelian stage may yet remain questionable.” Noetling in his preliminary note on the glacial

¹ E. Suess, Beiträge zur Stratigraphie Central-Asiens, Denkschr. K. Akad. Wiss. Wien, math. nat. Cl. LXXI, pp. 438, 439.

boulder beds of the Salt Range takes a different view (*loc. cit.* p. 84), considering these beds as well as the entire Productus limestone series as permian. But from a palæontological point of view a correlation of the Amb beds with upper carboniferous strata appears to be more adequate to their faunistic character.

The fauna of the lower Productus limestone (Amb beds) consists of 58 species, allowing an exact determination, 42 of which do not extend into higher strata but give to this division its peculiar aspect. It contains altogether sixteen species identical with forms found also in upper palæozoic rocks of other countries. All of them occur in upper carboniferous beds, but only twelve extend into permocarboniferous strata. This proportion is in favour of a correlation of the Amb beds with deposits of an upper carboniferous age.

The middle Productus limestone of the Salt Range has been considered as homotaxial with the permocarboniferous beds of Russia (Artinskian stage) by Tschernyschew. Waagen however admits this homotaxis for the Katta beds only, but correlates the Virgal beds with the permian limestones of Kostroma, "which are on a lower level than the great bulk of permian beds as exposed in Perm and thus are intermediate between the permocarboniferous beds of the Ural and the typical permian strata" (*loc. cit.* p. 194). The palæontological evidence is more in favour of Tschernyschew's view, which has been accepted by Rothpletz (*loc. cit.* p. 63).

Among the brachiopoda of the upper division of the middle Productus limestone (Virgal and Kálábagh beds) seven species only were known to Waagen as identical with upper carboniferous forms. By more recent investigations this number is now increased to seventeen. Among the Artinskian brachiopoda, as enumerated in Tschernyschew's tabular statement seventeen are identical with Salt Range types. Eight of them are ubiquitous ranging from upper carboniferous into permian strata. Of the remaining nine species two are restricted to the Amb beds, 1 to the Amb and Katta beds, 1 to the upper division of the middle Productus limestone. One extends from the Katta beds into permian strata, one from the Amb beds through the entire thickness of the middle Productus limestone, four are restricted to the upper division of the middle Productus limestone and to the upper Productus limestone. Excluding the ubiquitous species, which cannot be considered as leading, the distribution of identical species is as follows:—

4	{	Upper Productus Limestone : 4.
	{	Virgal and Kálábagh beds : 6.
7	{	Katta beds : 3.
	{	Amb beds : 4.

It will be seen from this tabular statement, that there is no sufficient reason for correlating the Artinskian stage with the Katta beds only, but that equally strong faunistic affinities exist between the Artinskian brachiopoda and those of the upper division of the middle Productus limestone.

There is no doubt that this statistical method of correlation is open to grave objections, as the admixture of a few species only would suffice to influence the

result considerably. It must be borne in mind that a comparison of the fauna of the middle Productus limestone with that of Artinsk is the more difficult, as no cephalopods are known from this Salt Range horizon, and we therefore must rely in our correlation almost entirely on brachiopoda alone, "which very generally do not keep strictly to an exact geological horizon and therefore can be used only in rare cases as reliable documents for the identification of a narrowly limited geological stage or zone." What I wanted to prove by this statistical method, is merely the fact, that there exist strongly marked affinities between the faunas of the Amb beds and of the Russian and Carnian upper carboniferous strata on one hand, and between the Artinskian and middle Productus limestone faunas on the other.

In the present state of our knowledge, the following modifications of Waagen's correlation of the Productus limestone series appear to be required. The lowest division of the uninterrupted sequence of marine beds, known as Productus limestone, is probably homotaxial with the topmost carboniferous strata in Europe. The equivalents of the Russian permocarboniferous horizon (Artinskian stage) must be looked for in the middle Productus limestone, but the question whether the boundary between the permocarboniferous horizon and the higher stages of the permian system ought to be drawn above the Kalabagh beds, cannot be answered, until cephalopod faunas have been discovered in one of the divisions of the middle Productus limestone.

The rich development of permocarboniferous or permian strata of a pelagic type in the Arctic region (Spitzbergen) is too little known to allow any exact correlation with the subdivisions of the anthracolithic system¹ in other countries.

The correlation of the permian deposits of a pelagic facies, according to the present state of our knowledge, is shown in the tabular statement on p. 105, it is, of course, only approximate, and in many instances yet open to grave doubts. Nevertheless I believe it to elucidate more clearly my views on this subject than would be possible in the text. In this tabular statement only such deposits have been admitted, whose correlation can be based on the presence of fossil remains. The Zechstein or magnesian limestone development of the permian system have been purposely excluded, because they do not represent a pelagic type of this system.

Having explained the present state of the permocarboniferous problem, I may enter now into a discussion of the relations existing between the fauna of the limestone crag of Chitichun No. I, and the faunas of homotaxial beds in other countries. This subject is so much more the important, as a determination of the geological age of the Chitichun limestone must be based on palæontological evidence only, the limestone crag itself exhibiting no stratigraphical connection with the surrounding beds.

It will be found convenient to treat each class of fossils separately, although

¹ I consider this term, which has been proposed by Waagen (*loc. cit.*, p. 241) very fit for uniting the carboniferous and permian systems under one name.

the palæontological evidence must chiefly rely on the brachiopoda, which by far predominate over all the rest of organic remains.

The two pygidia of trilobites can be of but little service for the identification of the geological horizon of the Chitichun limestone. One of them, *Cheiropyge himalayensis*, belongs to a new genus. The second, *Phillipsia Middlemissi*, may be compared to types, which have been found in upper carboniferous and permocarboniferous beds of other countries. Karpinsky (*loc. cit.* p. 101) considers the Artinskian stage as a period in the history of development of organic life, characterised probably by the appearance of the last trilobites, which do not extend into higher permian strata. The geologically youngest trilobites have been discovered in the permian Fusulina limestone of Sicily, but their absence in the permian rocks of India and Armenia is perhaps only accidental. Nevertheless the presence of trilobites in the Chitichun limestone corroborates the evidence adduced by the character of the entire fauna, that it does certainly not correspond to a higher level than to the permian of Sicily.

The discovery of *Stacheoceras Trimurti* is of the highest geological importance. Up to now ammonites of this subgenus have never been found of an older than permocarboniferous age, whereas they are among the most common types in permocarboniferous and permian strata of a pelagic facies. The occurrence of this species in the Chitichun limestone, in correspondence with other evidence, clearly proves this limestone to be of a younger than upper carboniferous age.

Five sixths of the entire fauna of the limestone crag of Chitichun No. I is composed of brachiopoda. Among them the *Productidæ* and *Spiriferidæ* are about equally strongly represented, whereas the *Lyttoniidæ*, *Porambonitidæ*, *Rhynchonellidæ* and *Terebratulidæ* are represented by comparatively few forms.

The following eight species of brachiopods are peculiar to the present fauna and have not yet been found outside the crag of Chitichun No. I :—

- Aulosteges tibeticus*, Diener.
- Spirifer tibetanus*, Diener.
- Martinia elegans*, Diener.
- „ *acutumarginalis*, Diener.
- Spirigerella pertumida*, Diener.
- Euteletes Tschernyscheffi*, Diener.
- Camarophoria gigantea*, Diener.
- Notothyris triplicata*, Diener.

To this list *Productus boliviviensis* var. *chitichunensis*, Diener, ought perhaps to be added, though its identity with a species from Timor is rather doubtful.

All the rest of species (31) are identical with forms that have been previously described from other countries and localities, although the exact age of the beds in which they occur has not everywhere been fixed with sufficient certainty.

The region, which is geographically least distant from Chitichun No. I, and in which the richest development of approximately homotaxial beds has hitherto been

made known, is the Salt Range in the Punjab. The relations of the fauna of the Salt Range Productus limestone and of the Chitichun limestone are very close. Twenty-six species of brachiopoda are identical. The greatest number are such forms, as occur in the upper division of the middle Productus limestone (Virgal and Kálábagh beds). These species are the following :—

<i>Productus lineatus</i> , Waagen.	<i>Spirigerella Derbyi</i> , Waag.
„ <i>Cora</i> , d'Orb.	„ <i>grandis</i> , Waag.
„ <i>cf. subcostatus</i> , Waag.	<i>Athyris Royssii</i> , Lév.
„ <i>gratiosus</i> , Waag.	„ <i>subexpansa</i> , Waag.
„ <i>Abichi</i> , Waag.	„ <i>capillata</i> , Waag.
<i>Marginifera typica</i> , Waag.	<i>Uncinulus timorensis</i> , Beyr.
<i>Lyttonia nobilis</i> , Waag.	<i>Camarophoria Purdoni</i> , Dav.
<i>Spiriferina octoplicata</i> , Sow.	<i>Dielasma biplex</i> , Waag.
<i>Spirifer musakheylensis</i> , Dav.	<i>Hemiptychina sparsiplicata</i> , Waag.
„ <i>Wynnei</i> , Waag.	„ <i>himalayensis</i> , Dav.
<i>Martinia semiplana</i> , Waag.	„ <i>inflata</i> , Waag.
	<i>Notothyris subvesicularis</i> , Dav.

Of these 23 species, more than half of the entire brachiopod fauna of Chitichun No. I, the following four do not extend into higher strata :—

<i>Spirifer Wynnei</i> , Waag.
<i>Martinia semiplana</i> , Waag.
<i>Dielasma biplex</i> , Waag.
<i>Hemiptychina sparsiplicata</i> , Waag.

All the rest occur also in the upper Productus limestone of the Salt Range but there is not a single species of the upper Productus limestone identical with a Chitichun form, which does not also occur in the middle Productus limestone. The affinity of the Chitichun fauna consequently appears to be more intimate with that of the middle than with the upper Productus limestone. This evidence is corroborated by the occurrence of a small number of species identical with such from the Amb beds and Katta beds, which in the Salt Range do not extend into higher divisions of the Productus limestone series. These species are the following :—

<i>Productus semireticulatus</i> , Mart.
<i>Reticularia lineata</i> , Mart.
<i>Martinia cf. glabra</i> , Mart.

On the other hand, there are among the Chitichun brachiopoda only ten identical with species from the Amb beds, and nine with those the Katta beds. Nor is there one of the three above quoted species, which could be considered as characteristic of a distinct geological horizon. This distribution of identical species indicates a homotaxis of the Chitichun limestone with the upper division of the middle Productus limestone (Virgal and Kálábagh beds,) in the Salt Range.

With upper carboniferous beds of Europe (Carnian Alps and Russia) the Chitichun limestone has ten species of brachiopoda in common. These are :—

Productus lineatus, Waagen.
 „ *Cora*, d'Orb.
 „ *semireticulatus* Mart.
 „ *cancriniformis*, Tschern.
Spiriferina octoplicata, Sow.
Spirifer musakheylensis, Dav.
Reticularia lineata, Mart.
Martinia glabra, Mart.
 „ *sempi plana*, Waag.
Athyris Royssii, Lé v.

There is not a single form among them, which is restricted to carboniferous deposits and does not extend into higher strata.

The two species of brachiopoda in the Chitichun limestone which have hitherto been found in carboniferous strata only, are *Productus mongolicus*, Diener, and *Martinia contracta*, Meek and Worthen.

Productus mongolicus is identical with a species from Loping in China, which has been described as *Prod. cf. cora* by Kayser, and has been compared to *P. compressus* by Waagen. The fauna of Loping is distinguished by a rather mixed assemblage of forms, notwithstanding its well marked carboniferous aspect. The question may therefore be raised, if *P. mongolicus* with its strong affinities to the permian *P. compressus* does not form part of the small fraction of permian types, which, like *Strophalosia horrescens*, Vern., are in this fauna mixed together with carboniferous species.

Martinia contracta has been quoted from the Chester group of the lower carboniferous series of Illinois, but it belongs to a group of forms, which are but very little adapted for the identification of geological horizons. I need only allude to *Martinia planoconvexa*, Shumard, which extends from devonian into permian strata without any variation¹. The presence of this species, therefore, cannot influence the evidence afforded by the general character of the fauna.

The relations of the Chitichun fauna to that of the Artinskian stage are more intimate than those with the faunas of any of the carboniferous stages of Russia. The following twelve species can probably be quoted as identical with Artinskian ones :—

<i>Productus lineatus</i> , Waag.	<i>Spirifer musakheylensis</i> , Dav.
„ <i>Cora</i> , d'Orb.	„ <i>Wynnei</i> , Waag.
„ <i>semireticulatus</i> , Mart.	<i>Reticularia lineata</i> , Mart.
„ <i>cancriniformis</i> Tschern.	<i>Martinia semiplana</i> , Waag.
<i>Marginifera typica</i> , Waag.	<i>Athyris Royssii</i> , Lev.
<i>Spiriferina octoplicata</i> , Sow.	<i>Camarophoria Purdoni</i> , Dav.

The nearest region to the Punjab and to Hundes, in which beds corresponding exactly in age to the Artinskian stage have been found, is Darwas. In

¹ *F. Frech*, in *E. Suess*, Beiträge zur Stratigraphie Central Asiens, Denkschr. K. Akad. Wiss. Wien., math. nat., Cl., LXI, p. 455.