Palæontologia Indica.

SERIES XV.

VOL. IV, PART II, FASC. No. 4.

FAUNA OF THE SPITI SHALES (LAMELLIBRANCHIATA AND GASTROPODA).

MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Palæontologia Indica,

BEING

FIGURES AND DESCRIPTIONS OF THE ORGANIC REMAINS PROCURED DURING THE PROGRESS OF THE GEOLOGICAL SURVEY OF INDIA.

PUBLISHED BY ORDER OF THE GOVERNMENT OF INDIA.

Series XV.

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By

Dr. KARL HOLDHAUS.

PLATES XCIV TO C.

CALCUTTA:

SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY, 27, CHOWRINGHEE ROAD
LONDON: MESSRS. KEGAN PAUL, TRENCH, TRÜBNER & CO.
BERLIN: MESSRS. FRIEDLÄNDER UND SOHN.

1913.

Part II (Pages 397–456).

The Fauna of the Spiti shales, Lamellibranchiata and Gastropoda, by Dr. KARL HOLDHAUS. Translated from the German by E. W. VREDENBURG.

FAUNA OF THE SPITI SHALES (LAMELLIBRANCHIATA AND GASTROPODA).

BY

DR. KARL HOLDHAUS:

(Translated from the original German by E. W. Vredenburg, Superintendent, Geological Survey of India.)

INTRODUCTION.

THE materials for the present study of the Bivalves and Gastropods of the Spiti shales were entrusted to me by Professor Uhlig. I must offer my heartiest thanks to Professor Uhlig for this favour, as well as for the constant help which he proffered me throughout the whole duration of the work.[1]

Great care has been bestowed upon the diagnoses in the descriptive portion of the work. If thereby many of the descriptions appear to have become inordinately long, it seems to me that such a copious treatment is justified by the highly interesting nature of the material, and the difficulty of obtaining access to the gréater part of the collection, preserved as it is in the Calcutta Museum.

It is unfortunately far too common in Palæontological literature to find new species of bivalves established without any exhaustive or correct diagnosis, and only a few trivial sentences to comment upon the illustrations. A correct description is not superfluous even with the best illustrations. The difficulty of studying the Palæontological literature referring to bivalves is greatly enhanced by the inaccuracy of many of the descriptions.[2]

With respect to the illustrations of the following work, a few remarks are needed. The illustrations in Plates XCVII to C were very carefully drawn by Mr. Fleischmann and are in every way correct. The execution of Plates XCIV to XCVI was entrusted to a somewhat less accomplished artist. Although I have spent much time and trouble over the correction of these plates, there still remain in some of the figures, a few inaccuracies which, in every case, are alluded to in the descriptive diagnoses.

GENERAL RESULTS.

I. Stratigraphical Results.—For several reasons the Bivalves do not possess from a stratigraphical point of view the same importance as many other groups of animals, the ammonites for instance. Consequently all the stratigraphical informa-

[1] The sad news of the death of Professor Uhlig was received shortly after this paper had been sent to

[2] I cannot avoid alluding here to Kitchin's admirable method of diagnosis as a standard worthy of imitation. His masterly monograph on the Trigoniæ from Kachh is one of the leading examples of systematic description.

tion that we can derive from a study of the Bivalves from the Spiti shales does nothing more than confirm the conclusions already arrived at from the Ammonites in that same formation. A few of the occurrences point to an Upper Jurassic age, as the most probable one for the Spiti shales: for instance, certain species of *Aucella* whose nearest allies are the European forms *A. Bronni* and *A. Pallasi*, and also a *Trigonia* closely related to several species from the Jurassic of Kachh (Chari group). The other Bivalves from the Spiti shales do not afford any precise indications of the age of the rocks.

The Spiti shales include two stratigraphical sub-divisions easily recognised from their lithological characters. The lower sub-division, known as the Belemnite beds, consists of grey friable shales crowded with Belemnites, while the upper sub-division constituting the Spiti shales proper consists of the well-known black compact silicified rocks whose appearance is extraordinarily characteristic. Of the Bivalves described in the following pages, the only ones belonging to the Belemnite beds are *Lima melancholica* and *L.* … *sp.*, *Inoceramus* sp. and probably also *Inoceramus* conf. *sularum* Boehm.[1] All the other specimens exhibit the lithological character and typical mode of preservation of the Spiti shales proper. Of the three gastropods, one species, *Cerithium* sp., must be from the Belemnite beds, while the other two are from the Spiti shales proper.

II. Palæofaunistic results.—In view of our very fragmentary knowledge of the Bivalve fauna of the Jurassic, the results yielded by a study of the Spiti shales fauna can only be of a provisional nature. A further difficulty arises from the circumstance that various genera of Bivalves differ considerably in their faunistic value. Side by side with forms, such as *Trigonia*, *Arca*, *Goniomya*, *Aucella*, endowed with exceptionally plastic specific features which render them of the greatest importance from the point of view of stratigraphy and zoogeography, we find other genera whose representatives, in widely separate geological formations and in regions situated far apart from one another, often exhibit a deceptive outward similarity which does not correspond with any true relationship.[2]

Amongst the forms represented in the Spiti shales, this is especially the case with the genera *Nucula*, *Astarte*, *Pleuromya*, and, to a certain extent also, such forms as *Inoceramus*, *Lima*, etc. It seems that, for the present at least, there is nothing scarcely to be done with these uncharacteristic genera, but to leave them out of account in all our faunistic and stratigraphical discussions.

Having all due consideration to the difficulties resulting from these various causes, we may state our conclusions regarding the Spiti shales fauna somewhat as follows:

[1] The Belemnite beds also contain some very badly preserved remains of a Bivalve which from its size and shape somewhat recalls a *Pleuromya*.

[2] We may reasonably presume that the specific distinctions although impossible to detect amongst the characters preserved by fossilisation originally found a clear expression in anatomical characters. A very conspicuous peculiarity in zoological groups, such as the Insects is the manner in which certain genera the representatives of which exhibit a remarkable external similarity nevertheless display strongly marked specific distinctions in their anatomy, while in the genera with very plastic external characters, the anatomical details exhibit scarcely any difference. In the same manner do we find striking specific distinctions expressed in the anatomy of many recent Gastropods and Bivalves.

1. The Bivalve fauna of the Spiti shales exhibits in many respects a thoroughly special and individualised facies. Though I have avoided adopting extreme criteria of specific differentiation, I am nevertheless unable to point out a single species as truly identical with the fossils from other Jurassic regions, if we leave out of account several species of *Astarte* which may be identical with some Kachh fossils. Some of the Spiti shales Bivalves are very peculiar and characteristic without any known representatives in other areas. This is particularly the case with the very remarkable new genus *Cosmomya*, which, so far, is not known anywhere else but in the Spiti shales; equally peculiar are *Goniomya Uhligi* whose peculiar ornamentation isolates it completely from all the other species of its genus, and also *Aucella formosa* and *Arca Egertoniana*. The last named species seems indeed to have been observed in Somaliland, and latterly also in Arabia.[1] With the exception of *Cosmomya*, all the Bivalves of the Spiti shales belong to wide-spread genera.

2. Regarding the faunistic relations of the Spiti shales Bivalves with those of other regions, I can express myself only with the greatest reserve. Some connection with the Jurassic fauna of Europe might be inferred from the rich development of *Aucellæ* whose nearest relatives are the Russian forms *Auc. Bronni* and *Auc. Pallasi*. At the same time one of the nearest allies of *Auc. Bronni* occurs in California (*Auc. Erringtoni*). The material gathered in Spiti does not afford any data of importance towards elucidating the question of the origin of the genus *Aucella*. It seems to me that, at the present stage of our knowledge respecting this subject, all we can do is to look upon *Aucella* as an almost cosmopolitan genus whose original centre of diffusion has not yet been detected. No serious conclusions can be derived from the resemblances of certain species of *Nucula*, *Lima*, *Pleuromya*, *Homomya*, with some of the Jurassic fossils of Europe.

The already mentioned occurrence of *Arca Egertoniana* in Somaliland and Arabia indicates a connection with the Jurassic fauna of Africa.

It would be very interesting to elucidate the relationship between the fauna of the Spiti shales and that of the Jurassic of Kachh. Unfortunately the rich Bivalve-fauna of the Kachh Jurassics is, as yet, very imperfectly known, though certain circumstances seem to suggest a close connection with that of the Spiti shales. *Trigonia spitiensis* from the Spiti shales is closely related to several forms from the Chari group of Kachh, and several species of *Astarte* of the Spiti shales appear to be either identical with certain Kachh fossils, or very closely related.

The Upper Jurassic fauna from the Sula Islands investigated by Boehm (Palaeontographica, Supplement IV, 1st part, 1904 and 1907) has yielded very few Bivalves. These include the genera *Inoceramus*, *Nucula*, *Anopæa* (?), *Mytilus* and *Lima*. The genera *Mytilus* and *Anopæa* are not known from the Spiti shales, while the Spiti representatives of *Nucula* and *Lima* are not identical with those from the Sula Archipelago. One of the species of *Inoceramus* from the Spiti shales, unfortunately in a very imperfect state of preservation, resembles *I. sularum*

[1] R. B. Newton and G. C. Crick. *Ann. and Mag. Nat. Hist.*, ser. VIII, Vol. II, 1908, pp. 1-29

Boehm from the Sula Islands, though it is not possible to say with certainty that the two forms are closely related. All the other *Inocerami* of the Spiti shales differ considerably from those of the Sula Islands.

THE BIVALVES.

The collections that have been placed at my disposal include 37 species of Bivalves distributed generically as follows: *Avicula*, 1 species; *Pseudomonotis*, 2 species; *Aucella*, 3 distinct species and one doubtful one; *Inoceramus*, 5 species; *Lima*, 4 species; *Pecten*, 2 species; *Nucula*, 5 species; *Leda*, 2 species; *Arca*, 1 species; *Trigonia*, 1 species; *Astarte*, 4 species; *Pleuromya*, *Cosmomya*, *Homomya*, *Goniomya*, *Pholadomya* and one undeterminable genus, each represented by one species [1]

Salter and Strachey's Palæontology of Niti includes descriptions of a certain number of Bivalves said to have been obtained from the Jurassic beds of Niti, but not represented amongst the Spiti collections sent to me. It is uncertain whether these species were obtained from the Spiti shales or from some older horizon. The collections are preserved in the British Museum and unfortunately I have been unable to gain access to them. As however it is still quite possible that all these forms, or at least some of them, may belong to the Spiti shales fauna, I append a list of their specific names:

Ostrea flabelloides Desh.—Salter.
„ *acuminata* Sow.—Salter.
Avicula inæquivalvis Sow.—Salter.
Pecten comatus Münster.—Salter.
Ostrea bifrons Salter.
„ *monilifer* Salter.
„ *sabal* Salter
„ *lens* Sow.—Salter.
Lima acuta Stopp.?—Salter.
Modiola sp.
Nucula sp.
Cardium truncatum Sow.—Salter.
Astarte or *Myacites* ?
Cucullæa leionota Salter.
Anatina vaginula Salter.

Genus: AVICULA, Klein.

AVICULA SPITIENSIS, Oppel. Plate XCVII, fig. 1.

Avicula spitiensis Oppel, *Pal. Mitt.*, I, 1862, p. 297, Pl. 88, fig. 5, *a*, *b*.

This species is represented only by two poorly preserved internal casts of the left valve, one of which is Oppel's original type from the Schlagintweit collection, adhering to a specimen of *Himalayites Seideli* Opp., while the other, about twice

[1] The fossil described and figured below as *Ostrea* sp. probably does not belong to the Spiti shales.

the size of the type-specimen, but unfortunately in a very imperfect state of preservation, bears the label: Lochambelkichak E.G., 19th July 1892.

The outline of the shell cannot be made out from either specimen. There are no distinct lines of growth. The oblique deflection of the shell towards the anal margin is very feebly indicated. In its dorso-anal region it expands into an extensive posterior ear, whose perfectly straight upper margin can be traced for a length of 6 mm. in Oppel's original specimen in which the total height of the shell is about 12·5 mm. The small umbo regularly tapering in a dorsal direction projects as far as 0·7 mm. beyond the upper margin of the posterior ear, but its termination is unfortunately concealed in both specimens. The anterior ear is not preserved. In a dorso-ventral and oro-anal direction, the shell is moderately inflated and very evenly curved, the flat posterior ear being connected with the convex portion of the shell by means of a concave furrow directed obliquely from the umbo towards the ventro-anal region.

The shell exhibits only radial ornamentation consisting of radiating ribs which may either assume the shape of sharp keels (as in the original type-specimen), or be less prominent and bluntly rounded. The ribs are very strongly developed in the marginal region, while they gradually become weaker towards the umbo, so that, on the internal casts, in the middle of the shell they disappear almost entirely at a distance of about 7 millimetres from the umbo. The original type-specimen still carries a few remnants of the shell in the neighbourhood of the umbo, giving one the impression that, on the outer surface of the shell, the ribs reached still further in that direction. In the convex portion of the shell, the ribs are not all of uniform size, but there is a very regular alternation of thicker and thinner ribs. The primary ribs constitute pronounced ridges distributed at approximately equal distances, the interval between two consecutive primary ribs being about 1·8 to 2 mm. at a distance of 12 mm. from the umbo. Mid-way between two consecutive primary ribs, there occurs a secondary rib which is not conspicuously, though always quite distinctly, less developed than the primary ones, and again in all the interstices between the primary and secondary ribs, there are tertiary ribs, extremely narrow and delicate and only just perceptible to the naked eye. From the state of preservation of the available specimens, it is unfortunately impossible to ascertain whether a similarly disposed radial ornamentation extended also to the posterior ear. In the original type-specimen, the posterior region of the subsisting portion of the ear carries a few shell-fragments which show a number of fine radial ridges following one another at intervals of 0·5 mm., and all equally developed.

Horizon.—Upper Tithonian to Neocomian.

Genus: Pseudomonotis, Beyrich.

Pseudomonotis inornata, n. sp. Pl. XCVII, figs. 2, 3.

This species is represented only by four specimens embedded in the usual matrix of the Spiti shales. The shell-substance has entirely disappeared with the

exception of some insignificant remnants of the inner prismatic layer. In every specimen the margins of the shell have been almost entirely destroyed. The lines of growth which are visible on an isolated specimen of the Schlagintweit collection indicate a moderate degree of obliquity for the left valve which possessed a broadly oval outline, its margin constituting a continuous curve. A height of 17 millimetres corresponds with a breadth of about 16 mm. The left valve appears considerably inflated and regularly rounded. The ears of the left valve are not preserved on any specimen. The umbo of the left valve is very strongly compressed in a dorso-ventral direction ; it is conspicuously incurved towards the median plane, its ventral margin being broadly and deeply excavated in a medio-lateral direction, so that the apex of the umbo is very strikingly curved downwards (Fig. 2*d*). On approaching the apex, the dorsal surface of the umbo is also directed downwards, with a very steep slope which becomes even almost vertical at the extreme end of the umbo in one of the Chidamu specimens, and it forms with the ventral margin of the umbo an angle of about 25°. The dorsal and ventral margins of the umbo meet in a slightly rounded edge. Seen from above the umbo has the appearance of an equilateral triangle. The size of the umbo varies.

There is only one imperfect fragment of a right valve—from Chidamu. Its ventral and anal regions are unfortunately broken. The lines of growth are not visible. The dorso-oral region assumes an exceptionally broad development, so that the pre-umbonal portion of the upper margin of the shell extends for a considerable distance in an almost straight line, passing by a sharp curve into the anterior margin at a distance of about 9 millimetres from the umbo. Apart from insignificant inequalities, the right valve is absolutely flat, and it is only in the neighbourhood of the umbo that a very shallow convexity can be seen. Looked at directly from above, the inner cast of the small umbo of the right valve has the shape of a sharply pointed three-sided pyramid, with three slightly rounded edges diverging from the apex. The lateral surfaces of the umbo are almost flat and slope steeply ventrally. The posterior marginal edge of the umbo runs obliquely in an almost straight line towards the ventro-anal region ; it is developed as a distinct edge only in the terminal region of the umbo, and, when followed towards the ventral region, assumes gradually the character of a shallow ridge which finally ceases to be appreciable at a distance of about 4 mm. from the umbo. The anterior lateral edge of the umbo maintains its distinct angular character for a greater distance than the posterior one, from which it diverges at an angle of about 45°. Along the continuation of its course it becomes more rounded and gradually bends round in an open and uniform curve till it lies horizontally. Up to its termination (at 4·4 mm. from the umbo), it remains parallel to the upper margin of the shell from which it is separated by a shallow furrow about 0·5 mm. wide.

The byssal region of the right valve is exposed. The internal cast exhibits a remarkably broad concave byssal notch whose dorsal limit is constituted by the rectilinear longitudinal notch of the byssal wing extending forward in a somewhat

oblique direction. The byssal ear can be followed up to a distance of 2·5 mm. from the apex of the umbo. The byssal notch which shows a slight and gradual increase of width in an oral direction is 2·2 mm. broad in its foremost portion.

The sculpture of the internal cast can only be made out in the two left valves of the Schlagintweit collection. The available specimens from Chidamu are obscured by an unevenly distributed incrustation resulting from the process of fossilisation, which conceals the sculpturing of the cast. Of the two internal casts of the Schlagintweit collection, the one seems almost smooth, while the other bears a very inconspicuous concentric ornamentation consisting of very slightly raised narrow folds of somewhat variable breadth, distributed at irregular intervals and totally absent from certain portions of the cast. The same internal cast exhibits local indications of very faint crowded radial lines, but it is uncertain whether these are to be regarded as merely accidental, or represent the remnants of a radial ornamentation. Moreover, there appears to be no trace of any ornamentation on the outer surface of the extremely thin shell; only in the umbonal region and the winged appendage does this attain any considerable thickness.

This form, when full-grown, attained truly remarkable dimensions: for instance, in one of the left valves in the Schlagintweit collection of which the ventral margin is unfortunately entirely missing, the lowermost preserved portion of the shell, which does not by any means constitute its lower margin, is 34 millimetres distant from the umbo.

Amongst the material to which I have had access, *Pseudomonotis inornata* is represented by two specimens both preserved in the same piece of rock bearing the label: "Chidamu E.G." Two more specimens occur in the Schlagintweit collection. Figure 2, Pl. XCVII represents one of the specimens from Chidamu, figure 3, one of those from the Schlagintweit collection.

It is not possible to form any clear notion regarding the relation of this fossil to other known Jurassic species; the apparent complete absence of any kind of ornamentation gives it a very isolated position amidst the representatives of the genus, most of which are decorated with strong radial ribs; this peculiarity connects it with *Pseudomonotis inops* Stoliczka. (Cretaceous Fauna of Southern India, Vol. III, p. 403, Pl. XXXVIII, figs. 7, 8) from the Arialur-group of Southern India, which also lacks radial ornamentation.

Pseudomonotis amœna, nov. sp. Pl. XCVII, fig. 4.

This species is represented only by two internal casts, showing both valves united, but unfortunately very badly preserved, with their margins completely broken. They are labelled: "Middle Spiti shales, Chidamu, 17, VIII". This form differs from *Ps. inornata* only in the feebler inflation of the left valve and the smaller size and different disposition of the umbo. The species evidently bear a close genetic relation to one another.

The left valve is very noticeably less convex than that of *Ps. inornata.* The umbo of the left valve is distinctly more delicate and smaller than in the case of *Ps. inornata.* As in the latter species, it is generally compressed in a dorso-ventral direction and turned inwards, but the ventral outline of the umbo in its terminal region, instead of being excavated in a medio-lateral direction as in the case of *Ps. inornata,* is perfectly straight and horizontal, so that the apex of the umbo is not curved downwards but is turned horizontally inwards (see fig. 4 *c.*) The dorsal and ventral outlines of the umbo meet in the apex at an angle of about 25°, the edge connecting the dorsal and ventral surfaces being bluntly angular. When seen directly from above, the outlines of the oral and anal sides of the umbo appear approximately rectilinear just as in the case of *Ps. inornata,* and converge towards the apex at an angle of 50° to 60°.

The right valve agrees in all essential points with that of *Ps. inornata :* the cast of the umbo has the same shape as in that species, though its edges seem more blunted, at least in one of the available specimens. The byssus-notch is particularly distinct in the case of one of the casts of a right valve : its base has the shape of a shallow curve, and it expands gradually in an oral direction, so that at its anterior portion it reaches a width of 2 millimetres. The longitudinal notch of the byssal ear can be detected up to a distance of about 2·4 mm. from the umbo, it appears quite straight and is disposed obliquely in a dorso-oral direction.

In every other character *Ps. amœna* seems to agree with *Ps. inornata.* No traces of ornamentation can be discerned in either of the specimens ; indeed the casts are coated with a film which is locally silicified. Both specimens are only of moderate size.

Genus : AUCELLA, Keyserling.[1]

The available material for studying this genus is fairly abundant and includes a series of specimens, all embedded in the characteristic matrix of the Spiti shales. In almost every instance the shell substance has been entirely weathered away, or is represented only by some scanty traces of the inner prismatic layer. The two valves are seldom preserved in contact with one another, most of the specimens consisting of isolated valves, or else of mere fragments lying in various positions within the matrix.

The available material is easily sorted out into four perfectly distinct species, of which *Auc. leguminosa* Stol. and *Auc. spitiensis* Holdh. are related to *Auc. Bronni* Rouill., from which however they are perfectly distinct, while *Auc. Blanfordiana* Stol. is closely related to *Auc. Pallasi* Keys. Whether *Aucella formosa*

[1] See particularly : J. Lahusen, Ueber die russischen Aucellen, *Mém. Com. Géol. St. Petersbourg,* 8, 1888, No. 1.
J. F. Pompeckj, Ueber Aucellen im fränkischen Jura, *N. Jahrb. f. Min.* 1901, Vol. I, p. 18.
J. F. Pompeckj, Ueber Aucellen und Aucellen-ähnliche Formen, *N. Jahrbuch f. Min.,* Suppl. Vol. XIV, p. 319.
D. Sokolow, Aucellen vom Timan und von Spitzbergen, *Mém. Com. Géol. St. Petersbourg,* Neuv. ser. livr. 36. (1908).

Holdh. really belongs to this genus is somewhat uncertain. We have, unfortunately, no information regarding the vertical distribution of the several species throughout the Spiti shales. Judging from the analogy of the Russian occurrences, where a considerable vertical interval separates *Auc. Bronni* from its derivative *Auc. Pallasi*, we may reasonably conjecture that *Auc. leguminosa*, *spitiensis* and *Blanfordiana* do not occur associated in the Spiti shales but are separated by vertical intervals. *Auc. leguminosa* and *Auc. Blanfordiana* probably represent respectively the oldest and newest term of a series of mutations, whose developmental tendencies exhibit the closest analogy with those expressing derivation of *Auc. Pallasi* from *Auc. Bronni* (obliteration of the radial ornamentation, concentric rippling of the shelly layer, involution of the umbo in the left valve, flattening of the right valve). The direct genetic relationship between *Auc. leguminosa*, *Auc. spitiensis* and *Auc. Blanfordiana* is perfectly plausible, though the material so far available does not include any passage forms between the three separate types. The fact that in every instance the available specimens of *Auc. spitiensis* and *Auc. Blanfordiana* were obtained from different localities strongly favours the notion that they belong to separate stratigraphical zones.

The study of the Spiti fauna has not furnished any fresh data to elucidate the problem of the origin of the genus *Aucella*. Apart from its occurrence in Europe and in the northern regions, and in the Himalaya, the genus has already been met with in California, in Mexico (numerous species), in Brazil and in New Zealand.[1] In the face of such a wide-spread distribution, it does not seem admissible to regard *Aucella* as an essentially northern element, nor is it possible to discuss the original focus of diffusion of the genus. With regard to its representatives in the Spiti shales, we must expressly emphasize the fact that they are not identical with the species of any other Jurassic region.

The abundance of individuals of *Aucella* in the Spiti shales and the varied specific development of the genus itself indicate that these organisms must have constituted an important element in the fauna of the Spiti ocean.

The materials for the study of *Aucella* so far obtained from the Spiti shales must be regarded as totally insufficient. The collection of fresh material with an exact record of the vertical distribution of the various forms is greatly to be desired.

AUCELLA LEGUMINOSA, Stoliczka. Pl. XCVII, fig. 5.

Aucella leguminosa Stoliczka. *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p 88, Pl. VIII, fig. 8.

Stoliczka's original specimen of *Aucella leguminosa* differs in many particulars from all the other Aucellæ of the Spiti shales and must be taken as the type of a

[1] *Aucella plicata* Fitt., Reise der œsterreich. Fregatte Novara um die Erde, Geolog. Theil, I Bd., 2, abteil., p. 32. Taf. VIII, fig. 4. This species, of which I have seen the types, is a true *Aucella*, very closely allied to *Auc. Pallasi* and *Auc. Blanfordiana*.

separate species. The shell is considerably elongated in an oro-anal direction, its length being 40 mm. while the maximum breadth is only 19 mm. It is also exceptionally oblique, even more so than *Auc. Bronni* Rouill. In lateral outline the left valve appears approximately rectangular, owing to the truncated appearance of the anterior part of the shell which throughout its entire breadth is rounded in a transverse direction. The dorso-anal margin, which, unfortunately, is only partly preserved, appears almost straight, its curvature, as in the case of *Auc. Bronni*, being probably very feeble. At its posterior extremity it is connected by a gradual curve with the terminal margin exhibiting a strong regular convexity, and curving gradually into the ventral margin, a considerable portion of which runs parallel to the dorso-anal margin. The ears of the left valve are unfortunately not preserved. The anterior half of the shell, especially near the umbo, is strongly and approximately regularly inflated, both longitudinally and transversely; distally it becomes gradually flattened. At about the anterior third of the shell, one notices in the ventro-oral half of the valve, an extremely shallow broad depression which is directed somewhat obliquely from the margin towards the umbo, but ceases to be perceptible before reaching the crest line.[1] The umbo is of moderate size, short, regularly conical, pointed, the apex bluntly rounded. It is deflected inwards and when examined from above exhibits only a very slight degree of anterior obliquity. Its ventral surface is practically horizontal at the terminal portion of the umbo, so that the umbo even at its apex does not show any trace of involution.

The right valve fits into the margin of the left valve and appears broadly expanded in its dorsal region. The terminal portion of the umbo and the ear are unfortunately concealed. In the byssal region the shell exhibits a narrow marginal zone curved inwardly, disposed obliquely in a medio-dorsal direction, and doubtless running into the base of the byssal fold. The right valve appears very strongly inflated in a transverse direction, especially in the proximal part of the shell. The situation of this zone of greatest convexity in the proximal part of the shell strongly differentiates *Aucella leguminosa* from all the other species of the Spiti shales and from *Aucella Bronni* and its European derivatives: instead of being situated along the longitudinal axis which passes through the umbo, it lies between the longitudinal axis and the ventro-oral margin. The region of the byssal fold and of the umbo itself is situated therefore on the almost plane dorsally sloping declivity of the shell. Distally the zone of greatest convexity gradually converges with the longitudinal axis.

The shell is very thin and its ornamentation can be clearly made out, especially on the left valve. The left valve is covered with extremely delicate, slightly wavy concentric lines, very slightly though very sharply raised, following one another at very close though somewhat variable intervals. The maximum distance

[1] According to Sokolow, this is defined as an imaginary line drawn along the lateral surface of the valve, and intersecting each successive line of growth at the point where it is farthest distant from the sagittal plane of the shell.

observed between two successive concentric lines is 0·9 mm., the average in the middle of the left valve being about 0·5 mm.; there are, however, some parts of the shell where the lines become much more crowded, followed by regions where they gradually die out, or become blended together. The shell substance has not been preserved in the immediate neighbourhood of the umbo, so that the concentric lines are first observed at 11 mm. from the apex, and are already distributed at the same intervals as in the distal portion of the shell. In addition to the concentric ornamentation one can distinguish upon both valves a system of exceedingly delicate radial lines separated by narrow intervals, and causing an undulation of the concentric lines at their points of intersection. In places where the radial ornamentation ceases, the concentric lines still exhibit locally a slightly contorted disposition, but only in a very irregular manner. In the left valve the radial ornamentation is distinctly developed only in the dorso-anal portion of the shell and can be detected up to within 11 millimetres of the termination of the umbo; nearer the umbo the preservation of the shell is unfortunately defective. The individual radial lines exhibit a downward directed convexity, and scarcely show any distinct thickening in a distal direction, while at a distance of 30 mm. from the umbo they completely disappear. The ventro-oral half of the shell scarcely shows any traces of radial ornamentation. The right valve was probably ornamented in the same way as the left one. Feeble concentric lines can only be detected at a single point in the neighbourhood of the terminal margin, but the radial ornamentation is perfectly distinct at about the middle of the valve and can be followed from there up to a distance of about 5 mm. from the umbo. This radial ornamentation spreads even on to the cast: at one place where the shell has been completely removed it is observed in the shape of perfectly distinct, extremely shallow radial stripes of feeble width (4 or 5 stripes to an interval of 1·7 mm.), while the concentric ornamentation, at that same place, only appears in the shape of a few extremely shallow folds of feeble width.

In addition to the above described delicate ornamentation, the left valve also exhibits in its ventro-oral portion, two broad, shallow concentric depressions, following each other at a moderate distance. They commence in the anterior part of the shell at a moderate distance from the umbo and follow the concentric lines in their posterior course, disappearing completely in the region of the terminal curvature of the concentric ornaments. The right valve is diversified in its posterior half by a few inconspicuous, very shallow rather irregular concentric depressions, of varying width (1·8 to 3·5 mm.).

The solitary specimen is from Kibber.

Aucella leguminosa differs from *Auc. Bronni*, owing to the still more pronounced obliquity and distinctly more slender build of its shell, the greater convexity and differently constituted umbonal portion of the left valve, the differently distributed convexity of the right valve, the distinctly finer concentric ornamentation, and the conspicuous development of broad concentric depressions in the ventro-oral region. From *Auc. spitiensis* and *Auc. Blanfordiana* it differs principally by its greater

obliquity, the development of a radial ornamentation, and the differently distributed convexity of the right valve.

The form described by Sokolow as *Auc. Bronni* var. *leguminosa* (Sokolow, Aucellen von Timan und von Spitzbergen, *Mém. Com. Géol. St. Pétersbourg*, Nouv. sér., livr. 36, pp. 8 and 27, Pl. I, fig. 4) is totally different from the true *Auc. leguminosa* as may readily be verified by comparing the illustrations.

AUCELLA SPITIENSIS, nov. sp. Pl. XCVII, figs. 7-13.

Under this name I have included a whole series of specimens which in many respects are intermediate between *Auc. leguminosa* and *Auc. Blanfordiana*. They are distinguished from *Auc. leguminosa* owing to their larger size, feebler obliquity, different shape and convexity especially in the right valve, and a totally different ornamentation. From *Auc. Blanfordiana* they differ by their distinctly greater obliquity, the different shape of the umbo in the left valve, the occurrence of broad concentric depressions in both valves, and perhaps certain differences in the ornamentation.

Aucella spitiensis when full grown, attains a considerable size : the largest available specimen is 70 mm. long, with a maximum estimated breadth of about 35 mm., while other specimens are nearly as large. The obliquity of the shell is approximately the same as in the case of *Auc. Bronni* Rouill. As in the case of *Auc. Bronni* the left valve exhibits a more or less pronounced elongate rectangular outline, the anterior portion of the shell appearing somewhat transversely truncated with a moderately pronounced, irregular convexity, while the oro-ventral margin remains practically rectilinear for a considerable distance, and runs almost parallel to the very feebly convex dorso-anal margin. The terminal margin exhibits a strongly convex outline, the convexity being somewhat more abrupt in its dorsal than in its inferior portion ; it is connected by a gradual curve both with the oro-ventral and dorso-anal margins. The left valve is strongly convex in its proximal portion, the convexity being regular in some specimens, irregular in others. Towards its posterior extremity the left valve becomes gradually flatter, so that in full-grown specimens the terminal portion appears almost plane or only very slightly convex transversely. The blunt umbo is usually short, massive, broadly rounded at its extremity ; it is horizontally directed somewhat obliquely inwards and forward, its ventral surface reaching the apex in an approximately horizontal direction. The umbo is of variable size. Of special interest is the constitution of the umbo in an immature specimen from Chidamu (fig. 11) ; the inner cast of the umbo is much compressed in a dorso-ventral direction, and, when viewed sideways, it exhibits the shape of a very sharp point in which the dorsal and ventral outlines of the umbo meet at an angle of about 30°. When viewed directly from above, the umbo of this specimen exhibits the shape of an obtuse triangle the apex of which is bluntly rounded. Nevertheless, this abnormal appearance of the umbo is to be regarded only as an individual variation. Most of the available specimens of the

left valve exhibit a very shallow, broad, transversal depression, with ill-defined boundaries, situated in the anterior part of the ventro-oral half of the shell; it commences at the anterior third, or nearer the middle of the rectilinear portion of the ventro-oral margin and extends towards the umbo along the lower part of the shell. It is completely absent from the variety *Auc. spitiensis superba* in consequence of the exceptional shape of the shell, but it is at least discernible in all other forms of the species. In those specimens of *Auc. spitiensis* f. typ., which exhibit an exceptionally distinct development of this feature, for instance in the specimen from Jandu, Sherik river, illustrated, in fig. 10, the depression reaches, with a gradual attenuation, as far as the "crest-line"; in other instances it ceases to be perceptible before reaching the "crest-line", or may even be restricted to the marginal portion of the shell.

The right valve is represented only by a small number of casts. It fits into the outline of the left valve, and is more or less broadly or narrowly obliquely oval. Transversely it is very feebly and regularly convex, longitudinally almost plane. The only specimens in which it is distinctly and irregularly convex both in a longitudinal and transverse direction are those which I have selected as types of the varieties *Auc. spitiensis extensa* and *Auc. spitiensis superba*. In contradistinction to what is observed in the case of *Auc. leguminosa*, the zone of greatest convexity actually corresponds with the longitudinal axis passing through the umbo. The umbo of the right valve has been preserved as an internal cast only in one single specimen[1]; it has the shape of a shallow, feeble projection with a blunt, rounded termination, its apex being situated very slightly, though distinctly lower than the portion of the upper shell margin situated behind the umbo. The same specimen exhibits the byssal notch and the longitudinal slit of the byssal ear (fig. 9) and thereby closely recalls the cast of a right valve from Novaya Zemlya illustrated by Pompeckj, in *N. Jahrb. f. Min.*, Suppl. Vol. XIV, p. 326.

Almost all the available specimens are in the condition of internal casts and do not show any trace of radial sculpture, but only concentric ornaments, which in most specimens assume the shape of extremely flat, rounded or slightly roof-shaped folds, separated from one another by intervals of varying width. The average interval between successive folds along the "crest-line" of the shell is about 2 mm., and is apt to increase towards the distal part of the shell. Near the umbo, the folds are not closer together, but rather wider-spaced than in the distally immediately following part of the shell. In one specimen of a left valve in the Schlagintweit collection at Munich, also in the condition of an internal cast, the concentric folds assume the character of very slightly raised lines, which, in the ventro-oral part of the shell, at a distance of 30 mm. from the umbo, follow one another at intervals of 0·8 to 1·6 mm. Close to the umbo they give place to folds of normal character. In exceptional cases the ornamentation of the cast becomes reduced to a few indistinct concentric folds, and there are more or less extensive portions of the surface of the cast devoid of all ornamentation.

[1] This right valve occurs in the same piece of rock as the left valve with an exceptionally small and pointed umbo that has already been alluded to (fig. 11).

In order to form some idea of the appearance of the outer surface of the shell we can dispose of only very scanty material, as there are very few specimens in which any trace of the shelly layer has been preserved. The few remnants of shell substance exhibit exclusively concentric ornaments in the shape of moderately raised fillet-shaped lines corresponding with the concentric folds of the internal cast. The concentric lines never show any trace of the waviness that characterises *Auc. leguminosa*.

A particularly characteristic feature of *Auc. spitiensis* is the occurrence of shallow concentric depressions of varying breadth (the maximum breadth reaching 3 to 7 mm.), which become especially distinct as they recede from the umbo. On the right valve these concentric depressions are usually less pronounced or totally absent. The left valve usually exhibits only one depression of this kind; sometimes there may be two or even three, following one another at moderate intervals; they are seldom totally wanting or indistinct in the case of the left valve.

Within the limits of *Aucella spitiensis* there are a number of forms which can be distinguished from one another by various peculiarities in their outward appearance, and which are not connected by intermediate gradations. They might just as well, therefore, have been regarded as separate species, and, if I have included them all under the collective appellation of *Auc. spitiensis* it is to conform myself to the broad conception of species which, after the example of Lahusen and Pompeckj, it is usual to adopt in the case of the genus *Aucella*. Moreover, it seems to me most probable that in spite of differences in their outward shape, all the forms here united under the name of *Aucella spitiensis* really represent synchronous variations of a single species.

The localities at which the various specimens were obtained are respectively mentioned under the heading of each separate variety.

Aucella spitiensis form. typ. Pl. XCVII, figs. 8-11.

The majority of the specimens belong to this form, the full-grown specimens of which are characterised by the slender or moderately broad, elongate shape of the shell, its relatively small size, and also the feeble development of the umbo in the left valve and the feeble, regular convexity of the right valve. The largest of the specimens which I have referred to this form (fig. 8) belongs to the Schlagintweit collection at Munich; its length is 55 mm., with a maximum breadth of 30 mm. Other specimens are decidedly smaller. The left umbo is always feebly developed, and in one specimen from Chidamu (fig. 11), its cast is produced into a sharp point. The right valve is transversely very feebly and regularly arched, longitudinally almost flat.

The specimens are from the following localities; Chidamu, Jandu E. G., Hundes.

AUCELLA SPITIENSIS EXTENSA, nov. form. Pl. XCVII, fig. 12.

One of the rock fragments from Chidamu contains two separate valves apparently belonging to one individual, and differing from the typical form of *Auc. spitiensis* in several noteworthy particulars. The left valve is extraordinarily elongated, considerably and irregularly convex transversely, with a remarkably deep concentric depression which is very pronounced along its entire extent, from its origin at the anterior margin of the shell up to its termination in the dorsal margin. The feeble umbo of the left valve is extraordinarily short and scarcely produced inward. The structure of the right valve, whose umbo is unfortunately not preserved, is particularly remarkable. Conformably to the elongated shape of the left valve, the right valve also exhibits a greatly elongated shape and feeble width. Its oldest portion near the umbo is almost flat in every direction and is connected outwards by means of a blunt rounded edge with a steep and almost rectilinear marginal zone. The flat median portion has a length of 30 mm. and a maximum breadth of about 15 mm. The declivous marginal zone is very steep in the ventro-oral part of the shell where it slopes at an angle of about 75°, but gradually loses in steepness while it increases in breadth towards the terminal part of the shell where the angle of slope becomes about 30°. The gradual decrease of the slope is not perfectly regular owing to the interference caused by two shallow concentric depressions which run into the declivous marginal zone.

This form is distinguished from *Auc. spitiensis* f. typ. owing to its elongated shape, the remarkable shortening of the umbo in both valves, and especially the aberrant distribution of relief in the right valve. Nevertheless it should be regarded, in all probability, as merely an individual freak.

AUCELLA SPITIENSIS GRANDIS, nov. form. Pl. XCVII, fig. 7.

A large fragment of rock from Chidamu includes a number of specimens all of which are remarkable for their considerable dimensions. The left valve illustrated in fig. 7 has a length of 70 mm. with a maximum breadth estimated at about 35 mm. The umbo is bluntly rounded at its extremity and is noticeably larger and thicker than in the case of *Auc. spitiensis*, and is strongly drawn inward. The concentric depressions are feebly developed and are distinct only in the ventro-oral section of their course. We do not possess any well-preserved specimens of the right valve. The unusual size and the powerful umbo distinguish *Auc. spitiensis grandis* from both the foregoing varieties.

AUCELLA SPITIENSIS SUPERBA, nov. form. Pl. XCVII, fig. 13.

Monotis concentrica Salter *in* Strachey's Pal. of Niti, p. 91, Pl. 22, fig. 4; *non* H. F. Blanford, *Journ. As. Soc. Bengal*, Vol. 32, 1863, p. 136, Pl. IV, figs. 6, 7.

This remarkable fossil which diverges widely from the typical form of *Auc. spitiensis* is represented by a single specimen from Niti which is preserved in the

British Museum, and which Salter described and figured as *Monotis concentrica* Blanf. This form is allied to *Auc. spitiensis* by the absence of involution in the umbo, the occurrence of deep concentric depressions in both valves, the distribution of relief in the right valve, which latter character discloses a close analogy to *Auc. spitiensis extensa*, from which it differs, however, as it does from every other form of *Auc. spitiensis* owing to its exceptional breadth (32 mm.) and reduced length (47 mm.) which, together with its feeble obliquity, combine to produce a very characteristic outline. The slight degree of obliquity recalls *Auc. Blanfordiana*. Close to the umbo, in the right valve, one observes an almost flat region, 23 mm. broad and 20 mm. long; this flat area is bounded on all sides by a rounded edge leading to an outwardly sloping marginal portion diversified with several concentric depressions.

The exceptional breadth of the shell recalls *Auc. Bronni lata* Trautsch.

The above description is from a plaster cast from which the illustrations, fig. 13, have also been drawn.

Aucella Blanfordiana, Stoliczka. Pl. XCVIII, figs. 1-9.

Monotis concentrica H. F. Blanford, *Journ. As. Soc. Bengal.* Vol. 32, 1863, p. 136, Pl. IV, figs. 6, 7; *non* Salter, Strachey, Pal. of Niti, p. 91, Pl. 22, fig. 4; *nec Aucella concentrica* Fisch., Keys. Reis Petschora-Land, p. 300.

Aucella Blanfordiana Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 88.

Aucella Blanfordiana is distinguished from *Aucella spitiensis* owing to its much less pronounced obliquity, the difference in shape and relief of its left valve, the constant involution of its left umbo, and generally a slightly different type of ornamentation, so that its general appearance is very distinct. The largest available specimen, unfortunately in an incomplete state of preservation, consists of a left valve from Jandu, Sherik river, with a maximum breadth of 33 mm. and an estimated length of about 60 mm. All the other specimens are much smaller.

The shell displays about the same degree of obliquity as in the case of *Aucella Pallasi* Keys. The left valve exhibits a rather wide range of variation in its shape and relief. When the shell is viewed laterally, the anterior truncation instead of being irregularly and feebly convex and approximately transverse as in the case of *Auc. spitiensis* is very distinctly oblique. The breadth varies considerably. In the case of full-grown specimens, the dorso-anal and oro-ventral margins remain approximately parallel throughout a considerable extent, and are connected by the terminal margin which is usually very regularly convex.

The left valve is strongly convex both in a longitudinal and especially in a transverse direction, becoming more flattened out towards the terminal region. Even in the umbonal region the convexity remains almost always regular and continuous, in a manner quite different from what is observed in *Auc. spitiensis*. Very seldom do we come across specimens with a discontinuous convexity, such as the one illustrated in fig. 5. The umbo is always large. It is strongly deflected inwards. Its ventral surface always appears deeply excavated when viewed in a medio-lateral

direction so that the apex of the umbo appears greatly curved downwards. Usually the shape of the umbo is relatively slender, though it may occasionally appear short and obtuse. The umbonal ears are not preserved in any of the available left valves.

The right valve exhibits a broad curvature in its dorso-oral portion; it is nearly flat longitudinally, feebly and regularly convex transversely, the region of highest relief corresponding with the longitudinal axis that runs through the umbo. The umbo is inconspicuous and scarcely projecting; none of the specimens show it in a satisfactory state of preservation. The impression of the byssal-notch is visible upon a few immature specimens of the right valve, where it constitutes a moderately deep rectilinear groove disposed almost horizontally, gradually widening in an oral direction, and somewhat deflected upwards close to the umbo. Its upper margin is limited by a low coil-shaped fillet, corresponding to the byssal ear and gradually disappearing towards the umbo.

The ornamentation of the internal casts consists exclusively of concentric ornaments in the form of very shallow folds of varying relief either roof-shaped or more or less rounded, distributed at variable intervals. These folds are sometimes disposed at regular intervals in series of perfectly equal relief, or else stronger and weaker folds may alternate irregularly. About the middle of the shell the distance between two consecutive folds varies on different specimens from 0·7 to 2·3 mm.; they are more crowded near the umbo than at the posterior part of the shell. In certain specimens where the folds are remarkably equal in size, and where they follow one another at very regular intervals of about 2 mm., the type of ornamentation becomes very similar to that of *Auc. Pallasi* Lah. Sometimes the concentric ornamentation of the casts becomes so scanty that they become almost smooth or only bear the merest traces of concentric decoration. Radial ornamentation is always wanting. The ornamentation of the shelly layer consists of prominent slender lamellæ, either sharply keel-shaped or more or less obtusely roof-shaped (fig. 9). The ornamentation of the right valve is distinctly more delicate and shallower than that of the left valve. There is a complete absence of concentric depressions such as characterise *Auc. leguminosa* and *Auc. spitiensis:* the only exception is in the case of an unusually large specimen from Jandu, Sherik river, illustrated in fig. 3, with a broad umbo which seems but slightly involute suggesting a tendency towards *Auc. spitiensis.*

Auc. Blanfordiana exhibits a considerable range of variation as regards general shape, structure of the umbo, and ornamentation. Unfortunately the material at my disposal is so poorly preserved, that I find it impossible to describe concisely the limits of the several forms, and to divide the species into varieties.

One rock fragment from Jandu, Sherik river, contains a whole brood of young individuals of *Aucella Blanfordiana*[1]; one of these small specimens is illustrated in fig. 2.

I have identified *Auc. Blanfordiana* amongst specimens from the following localities: Jandu, Sherik River (fig. 6); Kibber (fig. 1); Sirkia, south Hundes

[1] This same rock fragment contains specimens of *Oppelia (Streblites) pygmæa* Uhlig.

(figs. 5, 7); Niti Pass, N. Kumaon (fig. 9). A few specimens (figs. 4, 8) are of unknown origin.

Amongst species of *Aucella* from the Jurassic of Europe, the one most closely related to *Auc. Blanfordiana* is *Auc. Pallasi* Keys.; both species agree in all essential characters, such as the involution of the left umbo, the degree of obliquity of the shell, the great flatness of the right valve, and I find it impossible, for the present to establish any criteria that will in all instances clearly distinguish the two species. *Auc. Blanfordiana* is not closely related to any of the descendants of *Auc. Pallasi* such as *Auc. mosquensis* Buch., *trigonoides* Lah., *Fischeriana* d'Orb., *volgensis* Lah., etc., and other later species.

AUCELLA ? FORMOSA, nov. sp. Pl. XCVII, fig. 6.

This problematic species is represented by two isolated valves preserved as internal casts in a fragment of rock bearing the label: "Upper Spiti-shales (Etage III) Lochambelkichak E. G., 19th July 1892." The rock containing the two specimens is one of the characteristic concretions from the upper Spiti shales. The isolated left valve is of small dimensions, 13 mm. in length by 9 mm. maximum breadth; its obliquity is about that of *Auc. Pallasi*. The convexity near the umbo is only moderately pronounced both longitudinally and transversely, and the shell flattens out completely towards its margins. The crest of the convexity follows a line extending obliquely from the umbo to about the middle of the terminal margin with a slight convexity turned towards the oral margin. The umbo whose state of preservation is unfortunately not perfect is of very small size: its breadth at the level of the posterior ear is 2·2 mm., and it projects beyond the upper margin of the posterior ear by 0·9 mm. only. In the first third of its course, counting from the dorsal side, the oro-ventral margin exhibits a pronounced and regular convexity which gradually becomes lost towards the terminal part of its course where it becomes almost rectilinear. It is connected by an easy curve with the moderately convex terminal margin which, in its turn, is joined by a shallow curve with the dorso-anal margin. The maximum breadth of the shell is situated at about the posterior fourth of its total length. The pre-umbonal part of the dorsal margin is unfortunately not visible, but the post-umbonal portion exhibits the impression of a strongly developed posterior ear almost flat throughout its entire course connected with the shallow declivity of the convex part of the shell, by means of a very open re-entering angle. The ear assumes the shape of a very depressed oblique triangle, at the apex of which the short, nearly rectilinear and almost horizontal upper margin connects with the equally rectilinear posterior margin of the shell at an angle of about 140°. The almost rectilinear re-entering edge which bounds the ear along the convex part of the shell, can be followed in a ventral direction up to a distance of about 5 mm. from the apex, when it coalesces with the posterior margin of the ear at a very sharp angle.

The successive accretions are very delicately indicated on the cast where they give rise to a succession of exceedingly shallow concentric furrows of varying width. With a suitable illumination one can also detect in the anterior and central portions of the cast, a radial ornamentation consisting of excessively delicate, extremely shallow linear grooves.

The right valve is represented by one specimen of an internal cast of an immature individual. Unfortunately the umbonal region is not visible. The breadth is 5 mm., the estimated length about 6 mm. The shape is obliquely oval. Dorso-ventrally the cast appears almost plane, while in an oro-anal direction, especially near the umbo, it is relatively convex, the convexity gradually fading away with increasing distance from the umbo. The cast exhibits no other ornaments but a feeble growth-striation similar to that of the left valve.

The exceptionally small size of this shell, the remarkably small size of the left umbo, and the shallow convexity of the left valve, all tend to remove it somewhat from the typical members of the genus *Aucella*, to which I am nevertheless inclined to refer it. Unfortunately it is impossible to obtain certainty on this point because the byssal region of the right valve is not visible.

Genus: INOCERAMUS, Sowerby.

The genus *Inoceramus* is represented in the Spiti shales by five species. Three of these, *In. Everesti* Opp., *In. gracilis* Holdh., and *In. Stoliczkai* Holdh., occur exclusively in the black siliceous rock of the true Spiti shales. Two more very large, flat species occur in the Belemnite-beds. Unfortunately these two forms, which are hereafter described as *Inoceramus* sp. and *In.* conf. *sularum* Boehm, are very badly preserved. The last-named closely recalls the fossil from the Upper Jurassic (Oxfordian) of Taliabu island, described by Boehm as *In. sularum*, but considering its bad state of preservation, we are not justified in drawing any rigorous conclusions from its general appearance of similarity. The three forms from the true Spiti shales, *In. Everesti*, *gracilis* and *Stoliczkai* are not closely related to any of those described by Boehm from the Upper Jurassic strata of the Sula islands (G. Boehm, Beitrage zur Geologie von Niederlandisch-I dien, pt. 1, pp. 67 ff.)

INOCERAMUS EVERESTI, Oppel. Pl. XCVIII, figs. 12-14.

Inoceramus sp. Everest, *As. Research.*, Vol. XVIII, pt. 2, Pl. II, fig. 29. 1863.
Inoceramus Everesti Oppel, *Pal. Mitt.*, Vol. I, 1862, p. 298.
? *Inoceramus Hookeri* Salt. 1865, *in* Strach. Pal. of Niti, p. 95, Pl. 23, fig. 1.
? *Inoceramus Hookeri* var. *crenatulinus* Salt. *l. c.* p. 95, Pl. 23, fig. 2.
Inoceramus Hookeri Stoliczka, *Mem. Geol. Surv. Ind.* Vol. V, p. 89, 1865.

This species is represented by a number of specimens exclusively in the condition of internal casts. Both valves seem to be perfectly identical. They are very unsymmetrical, only slightly oblique, and greatly elongated ventrally, so that the height of the shell greatly exceeds its length. The anterior margin exhibits a more

or less regular shallow convexity and passes gradually, without any clear line of demarcation, into the strong convexity of the ventral margin, which, in its anal portion, is joined on to the anal margin by means of a gentle, continuous curve. The anal margin is quite rectilinear throughout a considerable extent of its course, the same disposition being reflected in the successive concentric ridges : for instance, one of the ridges whose maximum distance from the umbo is 34 mm. appears almost rectilinear in its dorso-anal portion for a length of 14 mm. Another ridge whose maximum distance from the umbo is 70 mm. has a rectilinear dorso-anal stretch of about 30 mm. The anal and dorsal margins converge at an angle of about 135°. In young specimens, however, the angle seems distinctly less. The upper margin is quite straight and carries ligamental pits throughout its whole length; in a specimen whose total height is 35 mm., the upper margin extends up to 15 mm. from the umbo. A large specimen from Lochambelkichak (fig. 12) exhibits clearly preserved ligamental pits which, in the middle of the ligamental margin, attain a length of 1·5 mm., and are separated from one another by intervals of 1·4 mm. The ligamental margin corresponds entirely with the level portion of the dorso-anal region.

The umbo is unfortunately badly preserved. It is situated in the anterior part of the shell. Near the umbo the shell is strongly convex both in a dorso-ventral and oro-anal direction. Ventrally the convexity decreases so that the ventral region is almost plane in a dorso-ventral direction and only slightly and regularly convex in an oro-anal direction. The "crest-line" follows a very steep course in a ventro-anal direction; conformably with the anterior position of the umbo, it comes very close to the anterior margin, especially in the dorsal region; ventrally the distance between the "crest-line" and the anterior margin gradually widens so that in full-grown specimens the "crest-line" comes to be situated near the middle of the shell in its lowest portion. The "crest-line" and the ligamental margin converge at an angle of about 60°. On the oral side of the "crest-line" the dorsal part of the shell slopes inward with a continuous curvature of increasing steepness so that its most anterior portion in the umbonal part of the shell lies nearly or completely in a medio-lateral direction. The steepness gradually decreases in the ventral part of the shell. On the anal side of the "crest-line" the slope is much more gentle, its steepness gradually lessens in an anal direction, so that the dorso-anal part of the shell appears quite plane and passes orally into the ascending part of the shell with a slight concavity. This zone of concave excavation extends obliquely from the umbonal portion of the ligamental margin towards the ventro-anal margin and diverges from the ligamental margin at an angle of about 30°.

The internal casts are ornamented with prominent concentric ridges, generally more or less rounded at their summit, or, more rarely acutely roof-shaped. Near the umbo the ridges are delicate and crowded; with increasing distance they become more prominent and wider-spaced. Moreover, the spacing of the ribs varies to a very noticeable extent in different specimens, and even in one and the same specimen successive intervals are apt sometimes to vary. The regularity of the concentric costation is further interfered with, owing to the fact that some of the ribs,

though distinctly developed along the region of the "crest-line", when followed in a dorsal direction, either dwindle away or coalesce with other ribs. Both in their dorso-oral and dorso-anal portions, all the ribs undergo gradually a considerable diminution in thickness and relief, the intervals between them being reduced at the same time. The point of greatest umbonal distance, that is the point at which the ribs bend round from a ventro-anal to a dorso-anal direction, is usually situated near the crest of the shell, though in many instances it may be slightly though distinctly displaced towards the anal side.

Full-grown individuals attain considerable dimensions, the largest available specimen being 90 mm. high.

Amongst the species from the Jurassic of Europe, we may mention *In. obliquus* Morr. and Lyc. (*Pal. Soc.*, VI, Great Ool. Moll., p. 24, Pl. VI, fig. 12) as presenting a certain degree of resemblance with *In. Everesti.*

In. Everesti has been obtained from the following localities: Middle Spiti shales, Shalshal, 22. VIII; Chidamu, 11. VII; Spiti shales, Hundes, Coll. T. L. Walker; Upper Spiti shales (Etage III), Lochambelkichak E. G. (figs. 12, 14); Camp Laptel, 26th August 1873; Upper and Middle Spiti shales, Kuti (fig. 13).

One more specimen, unfortunately in a very incomplete state of preservation, and which perhaps must also be included within this species, bears the following label: "Geode in black shales below Werfen beds. Doubtful on account of fossil, but no Spiti shales are found on the south slope of Niti Pass. N. W. Kimplung, S. W. Niti Pass". The specimen certainly does show the characteristic type of fossilisation of the Spiti shales.

Whether *In. Hookeri* Salt. and *crenatulinus* Salt. really correspond with *In. Everesti* Opp. could not be decided without a reference to the original specimens which I have not been able to examine.

Inoceramus gracilis, nov. sp. Pl. XCVIII, fig. 15.

This species is represented by a single incomplete cast of a left valve. It is probably closely related genetically to *In. Everesti*, but is distinguished by its much more slender shape, the different distribution of relief, especially as regards the far more pronounced oro-anal convexity, and by the much more oblique trend of the ligament-margin which is accompanied by a distinct marginal zone.

Both the ventral region and the umbo are unfortunately missing. The dorso-ventral convexity is relatively feeble, but the oro-anal one remarkably strong, though it becomes less pronounced in a ventral direction. The "crest-line" lies close to the median line of the shell even near the umbo, and converges towards the ligamental margin at an angle of about 30°. Both on the oral side, and especially on the anal side of the "crest-line", the surface slopes down steeply. On the anal side the slope is particularly strongly and regularly convex, so that in the dorsal portion of the shell the convex marginal portion is turned inwards, and therefore is

visible only from inside (fig. 15*c*). The ligamental and anal margins converge at a very blunt angle. Along its whole extent, the ligament margin is accompanied by an almost plane, unornamented marginal zone disposed exactly in a medio-lateral direction. Its breadth is 2 mm., and it is connected with the convex adjacent shelly surface by an obtuse re-entering edge slightly rounded at its apex. Instead of the slightly concave excavation observed in the dorso-anal portion of *In. Everesti*, we find, in the case of *In. gracilis*, a noticeably deeper and narrower chamber, which follows the uppermost part of the anal margin and gradually fades away ventrally. The oral marginal portion of the shell extends with a considerable breadth in a medio-lateral direction. Against the oral margin one observes a very shallow groove about 3 mm. broad, which on the internal cast is destitute of ornamentation.

A small fragment of the shelly layer subsists near the umbo. With the exception of lines of growth, it shows no ornaments. The anterior and ligament margins converge on the inside and somewhat medio-orally of the umbo at an angle of about 60°, the apex of which is truncated by a broad curve. The median declivity of the umbo ascends in a dorsal direction from the margin at a very steep slope, and gradually passes on to a vertical position through a continuous curvature.

The apex of the umbo which is unfortunately broken must have projected considerably beyond the uppermost portion of the ligament margin.

As in the case of *In. Everesti*, the ornamentation consists of concentric ribs which, in the neighbourhood of umbo, constitute very shallow narrow folds, while in a ventral direction they gradually acquire a considerable relief, their crest always remaining very narrowly rounded. In the umbonal portion of the shell, the region of maximum distance from the umbo does not correspond with the "crest-line", but is displaced considerably towards the anal margin, so that, when viewing the shell laterally, the orally sloping branch of the ribs nearest the umbo is alone visible. As the distance from the umbo increases, the point of greatest curvature of the ribs gradually approaches the "crest-line", so that at a distance of about 40 mm., the orally and anally sloping portions meet practically in the region of maximum relief of the shell surface. Just as in the case of *In. Everesti*, some of the ribs are developed only in the middle of the valve, their prolongations gradually dwindling away in a dorsal or anal direction, or else coalescing with adjacent ribs. The intervals between successive ribs are very variable, the maximum distance observed between consecutive ribs amounting to 5 mm. The terminal region of the umbo seems destitute of ornamentation.

The solitary specimen is from the Niti Pass in North Kumaon.

Inoceramus Stoliczkai, nov. sp. Pl. XCVIII, figs. 10, 11.

This species differs widely from both the foregoing. The specimen selected as the type is an isolated right valve (fig. 10), the exact locality of which is unknown.

It is preserved only as an internal cast. The shell is only very slightly oblique and must have exhibited a very broad, rounded outline. The dorso-ventral and oro-anal convexities are both feebly developed. The inner cast of the small umbo has the shape of a medio-laterally compressed cone, moderately tall and only slightly rounded off at its apex. The lateral surface of the umbo exhibits dorso-ventrally a continuous curve; it slopes ventro-laterally at an angle of about 45° in the terminal region of the umbo, while the median surface exhibits a very steep inward slope at the apex. The steep portion of the median surface of the umbo measures 1·4 mm. in height, and, with a curved bend, passes over medially to a horizontal course. When the valve is viewed directly on the flat, the umbo exhibits an angle of about 100°, its oral outline appears slightly concave and assumes an approximately horizontal direction on reaching a distance of 14 mm. from the umbonal apex. The anal outline exhibits approximately the same degree of slope as the oral one and at 5 mm. from the apex already reaches the level of the high-situated ligament margin.

Anteriorly to the umbo, the upper margin of the shell exhibits an unornamented marginal zone situated quite medio-laterally, connected with the flanks of the shell by means of a curvilinear bend. The width of this zone, as measured on the cast, is 6 mm. In the umbonal region this marginal zone exhibits a moderately steep curve in a dorso-anal direction and it extends obliquely backwards and upwards, finally passing on the inner side of the umbo where it merges into the post-umbonal marginal zone at an angle of about 100° without scarcely any curvature at the point of junction. The post-umbonal part of the upper margin is also accompanied by a medio-laterally disposed marginal zone, the anterior part of which is only 3 mm. broad as measured on the cast. The post-umbonal portion of the dorsal margin carries the ligament. The most anterior ligament pit is almost immediately adjacent on its anal side to the angle where the post-umbonal and pre-umbonal portions join. The anterior portion of the ligament margin is preserved as a cast in the above-described specimen (fig. 10*b*), the casts of the pits exhibiting the shape of oblong-oval cushions, the height of which distinctly exceeds their length (the length being measured oro-anally and the height at right angles to this direction). Their length is about 1·5 mm., their height about 1·7 mm. At about one-third of their total extent, measured from the ventral side, the rounded lateral borders of the successive ligament pits closely approach one another so that the intervening pillars (which, on the cast, naturally appear as cavities) exhibit at that level a minimum breadth, thence gradually expanding both dorsally and ventrally, so that at their upper end they attain a breadth of 0·6 to 0·9 mm. In every direction the boundaries of the casts of the ligament pits appear as sharply incised lines.

The ornamentation of the internal cast consists of concentric ribs which are broadly rounded at their summit. Their dimensions and spacing increase greatly in a ventral direction, the intervals amounting to 6 mm. in the ventro-marginal portion of the shell. The succession of the ribs is essentially irregular: some of the ribs are developed only in the middle of the shell, gradually dwindling orally and

anally, or else coalescing with other ribs. The position of greatest distance from the umbo lies somewhat towards the anal side.

There is one more specimen which should be referred to the same species and which consists of a right valve preserved as an internal cast (fig. 11). It bears the following label: "Middle Spiti Shales, Shalshal, 22, VIII." It is 40 mm. in length with an estimated height of 30 mm. It is very feebly oblique. The oral and anal margins combine with the ventral margin to form a semi-circle. The upper margin is connected with the oral and anal margins through a short bend. The umbo which occupied an approximately median position is not preserved. Dorso-ventrally the shell is very flat, while the oro-anal convexity is more distinct and regularly continuous. The "crest-line" extends nearly vertically downwards from the umbo. The ornamentation consists of shallow concentric folds increasing in dimensions and spacing with increasing distance from the umbo and distributed in very irregular succession.

Just as in the previously described specimen, the pre-umbonal marginal portion is drawn inwards, so that it is disposed medio-laterally; yet the turned-in marginal zone is connected with the flanks of the shell by means of a distinctly shallower convexity; it attains a considerable breadth near the umbo, becomes gradually contracted in an oral direction and disappears entirely in the foremost part of the upper margin. The ligament margin is situated high up, and can be recognised for a distance of 17 mm. On the inside of the umbo, it connects at an obtuse angle with the pre-umbonal margin which exhibits a dorso-anally directed curve in the umbonal region. Only in the neighbourhood of the umbo is the ligament margin accompanied by a distinctly developed medio-laterally disposed marginal zone which gradually disappears in an anal direction with increasing steepness. The characters of the ligament are essentially similar to those described in the case of the previous specimen, though the longitudinal dimensions of the ligamental pits attain as much as 2·3 mm., far more therefore than in the other specimen.

Inoceramus conf. Sularum, Boehm.

The following illustration represents a specimen of unknown origin, though probably obtained from the Belemnite beds. It is an *Inoceramus* whose ornamentation and feeble convexity recall somewhat *In. sularum* G. Boehm (*Palæontographica*, Suppl. IV, p. 70, Pl. XI, fig. 1). Owing to the poor state of preservation of the solitary specimen it is not possible however to identify it with certainty.

The shelly substance is preserved. The margins are all broken and the umbo is missing. The flanks are very feebly convex. The ornamentation consists of very shallow concentric ribs with broadly truncated crests, succeeding one another at considerable intervals. In the upper part of the shell the distance between

consecutive ribs is 7 or 8 mm., while the two lowest preserved ones are separated by a maximum interval of about 16 mm.

Inoceramus conf. sularum Böhm, natural size

Inoceramus sp.

The Belemnite-beds contain numerous impressions of a species of *Inoceramus* which, owing to their poor state of preservation can be neither identified nor described. The species attained very large dimensions, the estimated height of the largest available specimen being at least 130 mm. The ornamentation consists of wide-spaced shallow concentric ribs.

The locality and horizon of the specimens are: Chidamu, Lower Spiti shales.

Genus: Lima, Bruguière.

Lima melancholica, nov. sp. Plate XCVI, fig. 4.

The figured specimen has the shell substance preserved and is embedded in a grey friable shale. The only other specimen is a badly preserved cast. Both specimens are from Chidamu.

As will be seen from the figure, the shell is of small size, somewhat oblique, greatly elongated ventrally. In the region of both the anterior and posterior ear the dorsal margin does not seem quite intact. The anterior margin is almost exactly rectilinear and extends obliquely downwards and forwards. A pronounced convexity connects it with the rather shallow and regular convexity of the ventral

margin, the posterior portion of which combines with the posterior margin to constitute a continuous, shallow, and regular curve.

The convexity of the shell is regular and moderately pronounced. There is no visible lunula. The umbo is small and occupies an almost median position with reference to the dorsal portion of the shell. A considerable extent of its dorsal surface is directed almost horizontally towards a median direction. The terminal portion of the umbo is not exposed.

The outer surface of the shell is diversified both with concentric and radial ornaments. The concentric sculpture consists of a small number of distinctly visible lines of growth, besides which, in some of the best preserved portions of the shell, a strong lens reveals the presence of another set of lines of growth very close-set, sharp and of extreme delicacy. The radial sculpture consists of very shallow broadly flattened ribs, which are very delicate in the umbonal portion of the shell and gradually increase in breadth in a ventral direction. At a distance of 25 mm. from the umbo the radial ribs in the middle of the shell have an average width of 1 mm., the intervals being about half that amount. The breadth of successive ribs and the intervals between them are not quite regular. There is no distinctly visible ribbing in the anterior part of the shell on the oral side of the rib that extends from the umbo to the point of junction of the ventral and anterior margins. The few ribs which occupy that region in the published illustration were drawn from the artist's imagination. The same absence of radial ornaments is also observed near the posterior margin. The total number of distinct ribs on the flanks of the shell is 12.

The radial sculpture is somewhat different in the second badly preserved specimen mention of which has already been made and which I have nevertheless also referred to *Lima melancholica*. In size it approximately corresponds with the figured type. In the dorsal portion of the cast there is no trace of radial ornamentation, while the ventral half shows a distinct radial sculpture consisting of very numerous crowded, flatly rounded, keel-shaped very shallow ribs. This costation disappears in the neighbourhood of the anterior margin. The number of distinctly visible ribs is about 20.

Lima tristicula, nov. sp. Pl. XCVI, fig. 5.

This species is represented by a number of specimens, several of which have the shell preserved. They occur in the same shaly rock as *Lima melancholica*. They are from Chidamu.

The shell is of small size. The specimen represented slightly enlarged in Pl. XCVI, fig. 5, which is probably immature, has a height of 17·5 mm., the maximum length, which lies in the ventral third, amounting to 12·2 mm. Another larger specimen, probably full-grown, has a height of 24·5 mm. with a maximum length of 18 mm. The shell is unsymmetrical but only slightly oblique and is ventrally elongated. The greater portion of the upper margin is situated anteriorly to the umbo. This pre-umbonal portion is almost rectilinear and stretches obliquely forward

and downward, and connects with the anterior margin by means of a very obtuse rounded-off angle. The apex of the anterior ear lies about 5 mm. distant from the apex of the umbo in the case of the immature figured specimen and about 7 mm. in the case of the already mentioned adult individual. The post-umbonal portion of the upper margin is much shorter than the pre-umbonal one. It is likewise almost rectilinear, somewhat obliquely slanting backwards and downwards and is connected with the posterior margin by means of an obtuse rounded bend. The anterior and posterior margins are regularly and very slightly convex and are connected by a moderately strong convexity with the fairly flat bow-shaped lower margin.

With the exception of the flat ear the surface of the shell is feebly convex. There is no lunula. In the case of the full-grown specimen, the anterior part of the shell exhibits an extremely shallow broad concavity reaching obliquely from the umbo to the upper third of the anterior margin and dividing off the flat anterior ear from the convex portion of the shell. This concavity is not distinctly developed in the case of the immature specimen illustrated in fig. 5.

The small umbo is situated somewhat to the oral side of the posterior third of the upper margin. Its dorsal surface extends medially for a considerable extent in an approximately horizontal direction. The terminal part of the umbo is not exposed.

The surface of the shell is diversified both with radial and concentric ornaments. The only concentric ornaments visible to the naked eye in the dorsal part of the shell are a few feeble lines of growth, but with the help of a strong lens one can distinguish another set of extremely delicate lines of growth, very fine and very crowded. In the lowermost part of the shell there are some lines of growth visible to the naked eye, following one another at intervals of about 0·5 mm. The radial ornamentation consists of excessively flat, shallow, feeble ribs which almost disappear in the dorsal part of the shell. On the figured specimen, the ribs, in the ventral half of the shell, have an average breadth of 0·25 to 0·3 mm. and are separated by intervals of the same dimensions. In the region adjacent to the anterior margin, the radial sculpture is scarcely visible and the ribs observable in that part of the shell are not nearly so distinct as has been expressed by the artist in Pl. XCVI, fig. 5. In the case of the full-grown specimen, the internal cast is quite smooth and shows no trace of radial ribs even at its lowest margin.

Lima tristicula is not unlike *Lima melancholica*, but is undoubtedly and constantly distinguished by its somewhat smaller size, a smaller degree of obliquity, a somewhat shallower convexity, a different outline and its much finer radial ornamentation which shows absolutely no traces on the internal cast.

Lima Roberti, Oppel. Pl. XCVI, fig. 3.

Lima Roberti Oppel, Paläont. Mitteil., I, 1863, pp. 273, 298, Pl. 88, fig. 4.
Lima sp. Stoliczka, *Mem Geol. Surv. Ind.*, Vol. V, 1866, p. 89.

The available material for a study of this form consists of only two specimens, one of which is Oppel's type from the Schlagintweit collection, preserved at Munich,

and another specimen of unknown origin in a very fragmentary state of preservation belonging to the Calcutta Museum.

Both specimens are only in the condition of internal casts and display the characteristic appearance of the Spiti shales.

The shell is of considerable size, only slightly inflated, somewhat strongly oblique and produced in a ventro-oral direction. In the available specimens the margins are all broken and the ears are missing. From the disposition of the lines of growth, it is possible to ascertain that, in the immature specimen, the height of the shell was approximately equal to the width measured oro-anally. The anterior margin is connected with the ventral margin by means of a moderately strong convexity. The ventral and posterior margins combine to constitute a continuous, regular and fairly strongly convex curve.

The convexity both oro-anally and dorso-ventrally is regular and moderate. The umbo is moderately large, projecting somewhat considerably beyond the cardinal margin, rounded at its apex, not deflected inwards (unless this be at its extreme end which is broken off in both valves). The median surface of the umbo appears slightly excavated on the internal cast and becomes almost vertical towards the terminal portion of the umbo. It extends ventrally in an oblique direction with a gradual curvature.

The lunula is moderately broad; in the case of the fragmentary cast, which appears to have been somewhat larger than the figured specimen, the greatest breadth of the lunula measured across the united valves is about 17·5 mm. It is separated from the flanks by a ridge. When the shell is viewed anteriorly the ridge bordering the lunula seems to have a very feeble convexity and disappears in the immediate neighbourhood of the umbo. The greatest breadth of the lunula is situated at about one-third or one-fourth of its length measured from the dorsal side. In the neighbourhood of the umbo, the floor of the lunula is exceedingly flatly excavated in a transversal direction. In the ventral half of the lunula, the floor seems almost flat.

The ornamentation consists of radial ribs which are very flat and feeble in the neighbourhood of the umbo, so much so that they completely disappear in the immediate neighbourhood of the apex, while in a ventral direction they gradually acquire a considerable size. In the specimen illustrated on Pl. XCVI, fig. 3, the total number of distinctly developed ribs, including the one bordering the lunula, amounts to 19. Beyond the nineteenth rib (counting from the anterior end), in the posterior, medio-anally situated part of the shell, the radial ornamentation becomes much less distinct. The ribs seem to be much more delicate and, at the same time much more crowded than along the flanks. (In the illustration the ribs as shown in this part of the shell are far too strong and distinct). Along the flanks of the shell, the ribs are fairly regularly distributed. About the middle of the shell at a distance of 60 mm. from the umbo, the interval between two successive ribs amounts to about 4·7 mm. The ornamentation is particularly well preserved in the case of the inner cast belonging to the Calcutta Museum; in this

specimen, the ribs, throughout the greater portion of their course, have a sharp roof-shape, with an angular crest which becomes rounded off only near their ventral termination. In the figured specimen, however, the ribs, throughout their entire course, have their crest flattened and truncated in rounded fashion, perhaps as an effect of weathering. Exceedingly fine and very regular radial striations occupy the floor of the intervals between successive main-ribs. The number of these very fine striations in each interval is 13 to 14. In the anterior portion of the shell, however, the number of these fine striations becomes exactly double because another set of still more delicate striations are alternately interpolated between the normal set of fine ones. In the cast from the Schlagintweit collection, the lunula appears quite smooth. In the other cast, the lateral half of its floor in the right valve carries four very feeble, low, linear radial ribs at intervals of about 1 mm. With the aid of a lens, some excessively delicate longitudinal striations can be detected between these ribs. Traces of these exceedingly fine striæ are also visible with a lens in the median portion of the lunula.

The concentric ornamentation is very indistinct. On the specimen from the Schlagintweit collection it is reduced to a small number of inconspicuous lines of growth. The other specimen exhibits crowded striations of growth which are very close-set, but at the same time very feeble and indistinct.

Lima spitiensis, nov. sp. Pl. XCVI, figs. 1, 2.

This form is represented only by two internal casts with scanty remains of the shelly layer of both which I have referred to the same species though they differ in size and certain other characters. The larger specimen is from Kuling, the other from Kibber.

The shell is very large, rather strongly inflated, unsymmetrical, very oblique and elongated in a ventro-oral direction. The flanks are continuously convex, the specimen from Kuling being by far the more convex of the two. A considerable portion of the margins is missing in both specimens. In the larger specimen, the anterior margin remains almost rectilinear up to a distance of 80 mm. from the umbo. Beyond this distance, a strongly convex inflection connects it with the ventral margin which assumes the shape of a broad curve. At its dorsal extremity, the anterior margin converges with the short pre-oral cardinal margin at a very obtuse angle, whereby the anterior ear, observable on both specimens, is of greatly reduced dimensions. The posterior ear and the posterior shell margin are missing in both specimens. The cast of the large umbo, when viewed dorsally, terminates in the shape of a very obtuse triangle, the extreme apex of which exhibits a rounded truncation. When the shell is viewed from the anterior side, the umbo seems only feebly deflected inwards, with an angular apex; for a considerable distance on the larger specimen, and only a short distance on the smaller one, the dorsal surface of the umbo slopes obliquely inward at a shallow angle with a gentle curvature. The medially directed slope of the umbo is excavated with a fairly pronounced and

regular concavity ; its upper portion is overhanging. In the smaller specimen, the umbo is not so strongly deflected inwards as in the larger one.

There is a broad deep lunula separated off from the flanks by a rounded ridge disposed along a ventro-oral direction. This ridge merges into the anterior margin of the shell at a distance of about 80 mm. from the umbo in the case of the large specimen, while in the smaller specimen the estimated distance is 65 mm. The ridge bordering the lunula is more pronounced on the smaller specimen than on the larger one. When the shell is viewed from its anterior aspect the marginal ridge of the lunula exhibits a moderately convex shape. The maximum breadth of the lunula is situated at two-fifths of its total length, counting from the umbonal extremity. At that place, the width, measured across both valves, amounts to 40 mm. in the case of the Kuling specimen and 26 mm. in the case of the one from Kibber. The floor of the lunula slopes rather steeply from its marginal ridge towards a median direction. The small elevated anterior ear is bounded laterally by a broad shallow concavity, almost parallel to the anterior margin of the shell ; it becomes gradually shallower in a ventro-oral direction and can be followed all along the anterior margin to beyond the middle of the lunula.

The internal cast of the larger specimen exhibits excessively shallow, wide-spaced striations of growth which require a suitable incidence of the rays of illumination in order to become distinctly visible A very feeble radial sculpture is visible on both casts. On the larger specimen the radial sculpture, along the flanks, consists of slender very shallow striations distributed at close intervals and only visible with a suitable illumination. These striations almost disappear in the neighbourhood of the umbo, they become gradually more distinct when followed ventrally up to about the middle of the shell and once more fade away towards the ventral third of the shell. At about half the height of the shell, a distance of 5 mm. measured along one of the striations of growth includes about 4 radial striæ. The lunula, in the Kuling specimen, does not show any trace of radial ornamentation.

The ornamentation of the flanks is somewhat more distinct in the case of the cast from Kibber where it consists of radial lines of various strength distributed at somewhat irregular intervals and fading away towards the umbonal and ventral portions of the shell. This ornamentation is very well expressed in the illustration, though the delicate striations as shown on the post-umbonal region of the cast are distributed somewhat too regularly. In the Kibber specimen, the lunula also shows fine crowded striations which disappear towards the medial third of its breadth.

The only subsisting remnants of the actual shell are observed in the Kuling specimen where they occupy the region of the posterior ear and the marginal ridge of the lunula in the left valve. They include remnants of the inner and middle layers, both of which exhibit delicate crowded lines of growth, the fragment of the bordering ridge along the lunula also exhibiting fine radial striations which are visible even to the naked eye.

L. spitiensis belongs to the group of *L. gigantea* Sow. and, in its general appearance, it recalls the European upper Jurassic form *L. lœviuscula* Sow. (Min. conch

IV. p. 112, Pl. 382 ; Goldfuss, Petref. Germ. II, p. 79, Pl. 102, fig. 3). *Lima utaturensis* Stol. from the lower part of the cretaceous of Southern India (Utatur group) also seems closely related (*Pal. Ind.*, Cretac. Faun. of South. Ind., Vol. III, p. 417, Pl. XXIX, fig. 3).

The specimen from the Niti Pass mentioned by Salter as *Lima gigantea* Sow. ? may possibly belong to this same species.

Genus : Pecten, Klein.

Pecten inertulus, nov. sp. Pl. XCVI, fig. 7.

Amusium sp. conf. *Pecten Solidus* Trautsch. Stoliczka ; *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 87.

The only available specimen is the one shown in the illustration. It is an internal cast and bears the label "North of Kibber."

It is of small size and almost flat. The umbo and ears are missing. The ventral and lateral margins combine to form a continuous curve whose shape approximates to that of three quarters of a regular circle.

The ornamentation of the internal cast is reduced to three concentric, extremely shallow striations, whose average width amounts to about 0·5 to 0·6 mm. At a few places the cast also exhibits some very indistinct traces of linear radial striations.

Pecten sp. Pl. XCVI, fig. 6.

The figured specimen, a very fragmentary cast, is the only representative of this form and it is too imperfect for an accurate diagnosis. The surface of the cast is ornamented with eight conspicuous primary radial ribs, separated by intervals each of which bears from 7 to 9 much finer secondary ribs. The secondary rib occupying the middle of each interval is somewhat more conspicuously developed than its fellows.

The specimen is from the Upper and Middle Spiti shales of Kuti.

Genus : Ostrea, Lin.

Ostrea sp. Pl. XCVI, fig. 8.

Amongst the material to which I have had access, there occurs one specimen of an *Ostrea* of which I give a figure. It bears the following label " Spiti Shales, Gieumal (?)".

That this fossil really comes from the Spiti shales seems unlikely for the character of the rock differs widely from that of the Spiti shales. The shell is embedded in a reddish-brown pisolitic limestone which from its lithological aspect recalls the Kelloway rock.

Genus : NUCULA, Lamarck.

NUCULA SPITIENSIS, nov. sp. Pl. XCV, figs. 11-13.

Nucula cuneiformis H. F. Blanford, *Journ. As. Soc. Bengal*, Vol. XXXII, 1863, p. 135 and Stoliczka *Mem. Geol. Surv. Ind.* Vol. V, 1866, p. 90 ; *non* Sowerby, *Geol. Trans.* Ser. 2, Vol. V. Pl XXII, fig. 4.

This species is represented by a large number of specimens all of which have their shell preserved, but which are generally greatly distorted. They were obtained at Kibber, Chikkim and Gieumal.

As may be seen from the illustrations, the shell is of moderate size, moderately inflated, equivalve, very unsymmetrical, very much truncated posteriorly,[1] and greatly elongated anteriorly towards the oral margin. The dorsal margin remains almost straight for a considerable distance anteriorly to the umbo ; it is only on reaching the last third of its course, or a little before, that it becomes slightly deflected downwards through a slight gentle curve beyond which throughout the anterior third of its extent, it once more becomes rectilinear, and slopes very gently forward and downward. The anterior margin is connected with the dorsal margin by means of a short very convex curve, beyond which it extends very obliquely backwards and downwards. The ventral margin remains almost rectilinear in its posterior portion throughout a distance equal to almost half the total length of the shell and is connected at its oral extremity with the anterior margin through a gentle even curve. When the fossil is viewed in the ordinary manner, facing the flank of the shell, the posterior portion seems truncated by an almost straight line. The straight post-umbonal portion of the hinge-line extends at a very steep slope in a ventro-anal direction and converges with the pre-umbonal hinge margin at an angle of 110° to 120°. This post-umbonal portion of the hinge-line is much shorter than the pre-umbonal part and merges in a straight line into the posterior margin of the shell.

The strongly developed umbo is situated in the hindmost part of the shell. Its apex which comes almost directly in contact with the uppermost point of the hinge-line is obliquely deflected in a median direction. The angular edge limiting the lunula, and that of the small area on the umbonal apex, converge at an angle of about 100°, so that when seen from inside the apex of the umbo appears very angular. In a flank view of the shell, the dorsal surface of the umbo appears to slope backward rather obliquely with a gentle curvature for a distance of about 5·5 mm. When the shell is viewed from its anterior side, the dorsal surface of the umbo appears strongly and regularly convex, deflected downwards in a median

[1] With regard to the orientation of the shells of *Nucula* there is still a great deal of confusion both in palæontological and in zoological works. The anatomy of the animal indicates that the longest side of the unsymmetrical shell is really the pre-umbonal one and the shorter side the post-umbonal. Consequently in *Nucula*, the umbo is situated posteriorly to the middle of the shell, just as in the case of *Donax*, *Pisidium*, and many species of *Lima*, contrary to what one observes in most inequilateral shells where it occupies an anterior situation. See : Drew, Some observations on the Habits, Anatomy and Embryology of Members of the Protobranchia, *Anat. Anzeiger*, Jena, Vol. XV (1899), pp. 493-519 (especially fig. (2, p. 497) and Fred. Viès, Locomotion de la Nucule. *Bull. Soc. Zool. France*, Vol. XXIX, pp. 191-196.

direction for a considerable extent and disposed almost vertically in the immediate neighbourhood of the umbonal apex.

The rounded edge which borders the broad lunula merges into the shell margin almost exactly where the anterior and dorsal margins meet, so that the lunula occupies almost the whole length of the dorsal region. When the shell is viewed from the dorsal side, the marginal edge of the lunula is observed to follow a curvilinear course in which the curvature is greatest close to the umbo, and gradually becomes less pronounced as it recedes from the umbonal region. In the terminal third of its extent, or sometimes throughout almost half its length, the border of the lunula appears very feebly arched, or almost rectilinear. In the neighbourhood of the umbo the margin of the lunula distinctly shows the shape of an obtuse edge; it becomes gradually more rounded as it recedes towards the oral margin, but remains distinct up to the termination of the lunula. The greatest breadth of the lunula is situated at about half its length. Measured across both valves it amounts to 13 mm., in the case of the specimen represented in fig. 11. In the case of the specimen represented in fig. 12, its maximum breadth amounts to about 10 mm. Near the umbo the floor of the lunula slopes steeply inward. The direction of slope becomes reversed in an oral direction, so that at about half the length of the lunula the floor is practically horizontal, while throughout its anterior half it slopes gently outward. In the specimens illustrated in figs. 11 and 13, the floor of the lunula exhibits on either side an exceedingly obtuse indistinct swelling, which follows a curvilinear path diverging radially from the umbo, extends towards the terminal third or fourth of the total length of the pre-umbonal dorsal margin and disappears just before reaching it. This swelling does not seem to occur in the case of the specimen illustrated in fig. 12.

The area exhibits a very slender heart-shape. Its curvilinear marginal edge is obtusely angular in the neighbourhood of the umbo and becomes gradually more blunted and rounded as it recedes from the umbo. The floor of the area is perfectly flat in the middle, while at the sides it slopes towards the marginal edge.

The ornamentation of the shell consists of striations of growth, the development of which varies in different parts of the shell and in different specimens. The striations are delicate near the umbo, while at a greater distance they assume the appearance of delicate furrows. There are no radial ornaments. The hinge is concealed in every specimen and cannot be developed. There are no casts.

Blanford and Stoliczka referred either this species or the following one to *Nucula cuneiformis* Sow., from Kachh. Unfortunately I have been unable to obtain any of the Kachh specimens. Nevertheless, judging from Sowerby's illustration, it seems improbable that any of the Spiti species can correspond with *N. cuneiformis*. G. Boehm has given a short description of a species from Taliabu island in the Sula Archipelago, under the name of *Nucula taliabutica* (Palæontograph, Suppl. IV, 1907, p. 52, Pl. VIII, fig. 1). *Nucula spitiensis* is distinguished from this species by its different outline, much feebler convexity, larger umbo, the more pronounced marginal rim of the lunula and other differences.

NUCULA HYOMORPHA, nov. sp. Pl. XCV, figs. 14-17.

This species is represented by a small number of specimens with the shell preserved. They are usually distorted, but, instead of being compressed laterally as is generally the case with *Nucula spitiensis*, the compression takes place exclusively in a dorso-ventral direction.[1] Most of the specimens are without any record of their localities. One specimen bears the label " Chikkim ".

Nucula hyomorpha resembles *N. spitiensis* in its general appearance ; nevertheless a whole series of differences place its specific distinctness beyond any possibility of a doubt. The following description is restricted principally to a statement of the differences between the two species.

Nucula hyomorpha is on an average of a somewhat smaller size than *N. spitiensis*. It is distinctly more globose. One of the specimens is 26 mm. long, 8·5 mm. thick, and 17 mm. high. The flanks are distinctly more convex than on *N. spitiensis*. The most anterior third of the pre-umbonal dorsal margin is bent only very slightly with a gentle curvature. The anterior margin is distinctly more convex and less obliquely disposed than in *N. spitiensis*. It joins on to the dorsal margin with a shallow curve. The ventral margin exhibits throughout its entire length a very feeble curvature. When viewed from the flank of the shell, the umbo has its dorsal surface apparently more rounded than in the case of *N. spitiensis*. The structure of the lunula displays some very important differences. The angular bend, which, in the case of *N. spitiensis*, extends in an oral direction from the umbo and divides off the flanks from the medially disposed part of the shell, is invariably absent from *N. hyomorpha* whose flanks merge into the medially sloping dorsal region through a perfectly continuous, uninterrupted, regular convexity. All the well-preserved specimens exhibit a feeble, shallow, but very distinct obtuse edge, equally developed throughout its entire extent, situated close to the cardinal margin and extending in an oral direction from the umbonal region with a very feeble bow-shaped curvature. It merges into the pre-umbonal dorsal margin at the orally situated fourth or fifth of its total extent. This rim encloses a very slender lancet-shaped lunula, which is comparatively much narrower than that of *N. spitiensis*. Its maximum breadth is situated at about the middle of its course. In one specimen with a total length of 26 mm., the maximum width of the lunula measured across both valves is 3 mm. In another specimen 27·5 mm. long, it is 3·2 mm. The floor of the lunula slopes gently inward throughout its whole length.

The area is deep and has a much broader heart-shape than in the case of *N. spitiensis*. Its floor is flat in the middle, while the sides slope steeply towards the enclosing rim.

[1] This constitutes a constant distinctive mark from *Nucula spitiensis*, connected with the difference in the convexity of the shell. During the course of the sedimentation of the enclosing rock, the compression of the shell results from the weight of the superimposed sediment. After the death of the animal, the flat shell of *Nucula Spitiensis* probably rested on its side and was therefore laterally compressed, while the dead shells of the much more globose *Nucula hyomorpha* remained in a vertical position and consequently were dorso-ventrally compressed.

The concentric ornamentation is on an average somewhat finer and more regular than in the case of *N. spitiensis*.

Nucula hyomorpha recalls *N. taliabutica* Boehm from which it is distinguished by a smaller average size, a less exaggerated convexity, a more depressed shape and by the presence of a distinct rim round the lunula. One solitary specimen of *N. hyomorpha*, unfortunately very badly compressed, does indeed attain the same length as the specimen of *N. taliabutica* figured by Boehm on Pl. VIII, fig. 1 of his monograph.

The European Jurassic also contains some species exhibiting a general similarity to *N. hyomorpha*.

NUCULA KIBBERIANA, nov. sp. Pl. XCIX, fig. 1.

This species is represented by a solitary somewhat crushed specimen from Kibber.

Nucula kibberiana is at once distinguished from the two preceding species owing to its shape which is much less elongated orally. The solitary specimen is 18 mm. high, 22 mm. long and 13 mm. thick. The pre-umbonal dorsal margin remains almost rectilinear up to a distance of about 14 mm. from the umbo beyond which it merges into the anterior margin with a gentle curvature. The anterior margin shows a somewhat pronounced regular convexity ; its ventral portion combines with the ventral margin to constitute a rather extended, uniform, arc-shaped curve. The posterior portion of the shell is distorted. The umbo is large, situated in the posterior part of the shell and similar in shape to that of *Nucula spitiensis*.

The lunula has a length of about 13 mm. with an estimated maximum breadth of 6 mm. Unfortunately the shell is somewhat distorted in the region of the lunula. The lunula is divided off from the flanks by means of a very indistinct marginal ridge of bluntly rounded outline which follows a curvilinear trend from the umbo towards the oral margin and already ceases to be perceptible at about 10 mm. from the umbo. The area is greatly distorted ; apparently it had a slender cordiform shape.

The ornamentation is similar to that of *Nucula hyomorpha*.

NUCULA sp. Pl. XCIX, fig. 2.

The internal cast illustrated in fig. 2, Pl. XCIX, does not seem to agree with any of the above-described species. The only indication of locality recorded on the label is " Spiti valley."

It is of moderate size, very convex, greatly elongated in an anterior direction. The maximum length measured in a direction parallel with the pre-umbonal dorsal margin is 17·8 mm. ; the height measured from the middle of the dorsal margin to the middle of the ventral margin is 12·2 mm.[1] ; the thickness is 11·8 mm. The

[1] In the illustration the height is shown too great by about 1 mm.

umbones are situated in the hindmost part of the shell. The pre-umbonal portion of the cardinal margin is rectilinear throughout a considerable extent of its course; it bends round at an angle into the much shorter post-umbonal cardinal margin. The dorsal portion of the anterior margin is broken; its ventral portion combines with the ventral margin to constitute a fairly strongly and regularly convex, arc-shaped curve. The posterior end of the shell exhibits an almost rectilinear truncation. The cast of the umbo is large, regularly pointed, with a rounded truncation only at the extremity of its slender apex. The medially situated slope of the umbo is excavated by a moderately deep arc-shaped concavity which bears the impression of the ligament in the shape of a tall, rather narrow, very feebly impressed triangular excavation. The apex of the umbo is situated about 2·3 mm. above the deepest part of the ligament impression. Along the laterally directed slope of the umbo, one notices a very shallow, slender, short radial furrow, breaking up, in a ventral direction into two branches which soon cease to be distinct. It is not distinctly shown in the illustration. The muscular impressions are strongly developed and stand out in relief over the surface of the cast in the portion facing the umbo. The pallial line is not visible. A broad furrow trends from the anterior part of the posterior muscular impression towards the umbo; it becomes narrower as it is followed dorsally and disappears at about 3 mm. from the apex of the umbo.

The cast exhibits a broad lunula encircled by a very blunt rounded edge which extends with a curvilinear outline from the umbo towards the oral margin and gradually disappears in an anterior direction. In its median portion the lunula bears the impression of strong cardinal teeth, the exact number of which cannot be ascertained. The length of the lunula is about 12 mm.; its maximum breadth which is situated at about the middle of its length is about 6·5 mm.. In the posterior portion of the shell there is a feebler bluntly rounded curvilinear edge extending from the umbo to the middle of the posterior muscular impression. The region thus enclosed on the posterior portion of the cast comes to resemble an area with a height of 8·5 mm. as measured from the apex of the umbo and a maximum breadth of 6·2 mm. measured at about half its length.

In its ventral portion the cast exhibits a number of indistinct concentric striations of growth.

NUCULA DIENERI, nov. sp. Pl. XCIX, fig. 3.

Nucula sp., Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 90.

This remarkable species is represented by a single internal cast from Gieumal.

It is of small size, fairly strongly convex, almost equilateral. Its length is about 10·6 mm., its height 7·5 mm., and its thickness 5·5 mm. The cardinal margin only exhibits a most feeble degree of curvature. It is practically rectilinear throughout its whole extent and there is no angular bend at the junction of its

pre-umbonal and post-umbonal portions. In an oral direction the dorsal margin passes into the anterior margin by means of shallow curve. The anterior margin is unfortunately to a large extent missing. Its ventral portion combines with the ventral margin so as to constitute a continuous, regular, fairly shallow arc-shaped curve. From the general aspect of the specimen, the pre-umbonal portion of the shell seems to have been very little, if at all, more elongated than the post-umbonal one, though distinctly taller.

The shell is fairly convex both in a dorso-ventral and oro-anal direction. There is neither lunula nor area.

The umbo is small and extends very little beyond the cardinal margin. It is directed approximately medially and is only very slightly deflected inwards in a horizontal direction. When the shell is viewed from the flank, the umbo exhibits the shape of an obtuse triangle with rounded-off apex. Viewed dorsally, the terminal portion of the umbo seems very obtusely and broadly rounded. When viewed from the anterior side, the dorsal surface of the umbo appears almost horizontal for a certain distance and does not slope medially until quite close to the apex.

The surface of the cast is perfectly smooth without any distinct impressions of the muscular impressions or of the pallial line and without any indication of concentric or radial ornaments. Except along the cardinal line, the margins of the cast are everywhere grooved by a very shallow concavity, scarcely 0·5 mm. wide.

The impression of the hinge apparatus is fairly well preserved. The impression of the cardinal ridge constitutes a narrow furrow extending for a distance of about 3·2 mm. on the oral side of the umbo, and of about 2·3 mm. on the anal side. Towards the middle of the cardinal line the impressions of the teeth are rather well preserved. The pre-umbonal portion of the cardinal margin bears at least 15 small teeth (the exact number cannot be quite ascertained). The post-umbonal portion bears about nine which are distinctly larger than the anterior ones. I have been unable to observe any teeth in the portion of the cardinal margin situated immediately between the umbonal apices which are not clearly exposed.

Nucula Dieneri belongs to a group of species which is represented by a whole series of forms in the Jurassic of Europe. The species described by Borissjak as *Nucula* cf. *subovalis* Goldf. from the Bajocian of the Donetz appears to me very similar. (Nuculid. der Jura ablag. des europ. Russland, *Mém. Com. Géol. St. Pétersbourg*, new series, fasc. 11, p. 41, Pl. II, fig. 13).

Genus: Leda, Schumard.

Leda spec. Pl. XCIX, fig. 4.

This species is represented by a solitary badly preserved internal cast which was obtained between Chidamu and the Kiangur Pass.

The illustration gives an idea of the outline of the shell, though the anterior margin in its upper half exhibits a stronger and more regular convexity than would appear from this figure. In the post-umbonal part of the shell the margins are not

intact. The shell is feebly and regularly convex. The umbo is low and of moderate size. The cardinal margin is not visible. The ornamentation of the cast is restricted to a few very shallow unequally developed striations of growth. The specimen cannot be more exactly described owing to its poor state of preservation.

LEDA ? sp.

Another solitary cast which is very incompletely preserved probably also belongs to the genus *Leda* but is not in any way identical with the foregoing species. It bears no record of its original locality.

The specimen is of small dimensions. It is rather strongly convex and greatly elongated in an anal direction. The margins are broken almost throughout their whole length. The anal portion of the shell is contracted. The umbo is situated approximately at the anterior third of the shell; its terminal portion is not visible. With the exception of a few very indistinct striations of growth, the cast does not exhibit any ornaments. The muscular scars and pallial line are not visible.

Genus: ARCA, Lamarck.

ARCA (CUCULLÆA) EGERTONIANA, Stoliczka. Pl. XCV, figs. 1-10.

Arca sp., Herbert, *Glean. in Sc.*, Vol. III, 1831, p. 272, Pl. XVII, fig. 6.
Arca sp, Everest, Asiatic Researches, Vol. XVIII, Pt. 2, 1833, p. 114, Pl. II, fig. 27.
Cucullæa virgata, H. F. Blanford, *Journ. As Soc. Beng.*, 1863, p. 136; *non* Sowerby *Trans. Geol. Soc. London*, 2nd ser., Vol. V, Pl. XXII, fig. 1.
Macrodon Egertonianum Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 89, Pl. VIII, fig. 7.

The available material includes fifteen more or less satisfactorily preserved specimens all with the shell completely preserved. In most cases those specimens in which both valves are united are greatly distorted, and almost invariably compressed in a dorso-ventral direction.

The shells exhibit a relatively strong convexity and are greatly elongated in an anal direction, so that in full-grown specimens the post-umbonal part of the shell is often more than three times the length of the part situated in front of the umbo. The rectilinear hinge margin connects with the anterior margin at a distinctly acute angle, which in only a few specimens becomes a right angle in consequence of a truncation affecting only the extreme end of its anterior extremity. The anterior margin exhibits a shallow curvature and passes gradually into the lower margin without any distinct point of separation. In full-grown specimens the lower margin is almost straight throughout a considerable distance; it trends obliquely backwards and downwards so that it diverges considerably from the direction of the cardinal margin. The lower margin of the left valve always occupies a somewhat inferior position relatively to that of the right valve. In the case of well-preserved full-grown specimens the oblique rectilinear posterior margin converges with the hinge-line at an angle of 120° to 130° which is truncated by a

short curvature only at its extreme summit. The degree of convexity does not vary much: an isolated left valve 48 mm. long has a depth of 18 mm., while in the case of another valve 47 mm. long, the depth is 15·5 mm. When the shell is viewed from above, the outline of each flank exhibits the shape of a curve whose maximum convexity is in the middle, while it flattens out quickly towards the oral and anal extremities. When the shell is immature, its anterior portion, as seen from above, is drawn out in the shape of a beak. In full-grown specimens it is more or less broadly truncated, the truncation appearing either as a very obtuse angle or quite flat. The anal termination always appears sharply pointed. The umbo is moderately involute at its apex; it is of moderate size and obliquely deflected forward and inward.

The ligamental area varies a great deal in breadth; in one specimen of an isolated right valve with a length of 48 mm., its breadth measured on the inside of the umbo, is 8 mm., while in another specimen of almost equal dimensions (length 47 mm.), its breadth is only 6 mm. In its middle region the area is quite flat and horizontal, while, towards its margins in the region of the umbo, it exhibits, in the case of full-grown specimens, a pronounced slope, so that the apex of the umbo is raised about 1·5 mm. above the level of the median portion of the area. The margin of the area assumes more or less the shape of a sharp edge. The pre-umbonal portion of this marginal edge is always more or less obtuse and after a prolonged almost rectilinear course, it is abruptly inflected inwards so that, in full-grown specimens, the ligamental area always more or less exhibits a broad transverse truncation. The truncated portion may attain a breadth of 4 mm., as measured across one valve near the umbo the pre-umbonal margin of the area is distinctly raised above the floor of the area. The post-umbonal margin of the area follows an almost rectilinear course almost parallel with the hinge-line up to a distance of about 21 mm. from the umbo, beyond which it gradually approaches it and finally converges with it. The angle of convergence, in the case of full-grown specimens, is 75°. In the case of full-grown specimens the post-umbonal margin of the area is distinctly raised above the floor of the area as far as a distance of about 18 mm. from the umbo, the distance between its crest and the floor of the area amounting to about 1·8 to 2 mm. in the immediate neighbourhood of the umbo. This post-umbonal marginal edge is sometimes very sharply angular, but in the majority of cases the angle is more or less truncated. The ornamentation of the area consists of fine striations bending at an angle on the inside of the umbo, and trending backwards and forwards towards the hinge-line which they meet at an angle of about 20°. The points of inflection of successive striations form a straight line trending somewhat obliquely inwards and backwards. These ligamental striations do not occupy the entire surface of the area but are separated from its margin by a zone of varying width which shows nothing but the normal lines of growth. In the post-umbonal part of the area this marginal zone has a maximum breadth of 1·7 mm., its inner boundary is quite sharp and runs in equal distance from the outer marginal rims of the area fairly throughout its whole extent. In the pre-umbonal

part of the area this inner border may either run parallel with the outer marginal rim of the area and share in its curvature, (fig. 1*d*.) or else it may follow an almost rectilinear oblique trend towards the anterior end of the hinge-line. This disposition is observed principally in specimens with a relatively narrower area and, when this is the case, the marginal zone, characterised by the presence of lines of growth, instead of forming a continuous border of approximately constant breadth, constitutes a very obtuse triangle (fig. 3*c*). With a sufficiently abundant material, both extremes would be found connected by every possible intermediate gradation. One of these intermediate types is illustrated in fig. 9.

The structure of the hinge is visible in two isolated left valves and in the anal portion of one right valve. In the case of the left valve the anterior portion of the hinge exhibits two powerful ridge-shaped teeth separated by a furrow which gradually contracts in an anal direction. The uppermost of these teeth is parallel with the upper margin of the hinge-plate and is separated from it by a narrow furrow, while the lower tooth is somewhat obliquely disposed and converges noticeably in an anal direction towards the upper tooth. In the case of one specimen, which, in the middle part of the hinge, is unfortunately in a poor state of preservation, the upper tooth can be followed backward almost as far as the umbo, while the lower tooth disappears much sooner and attains a length of not more than 4·6 to 5 mm. in the case of valves 47 to 48 mm. in length. Both teeth approach within 2 mm. of the anterior margin. The lower tooth is best developed at its anterior extremity and loses gradually in breadth and height when followed backward. One of the specimens shows indications of a third tooth situated on the ventral side of the second tooth, in the shape of a short very oblique edge-shaped protuberance. The posterior portion of the hinge, in the left valve, also shows two powerful ridge-shaped teeth converging in an oral direction. The upper tooth is separated from the lower one by a deep furrow which gradually contracts anteriorly; it is parallel to the upper margin of the hinge-plate and is separated from it by a narrow and shallow furrow. Below the lower dental ridge there is still a rather narrow and shallow dental furrow. The middle portion of the hinge is unfortunately very much weathered in both specimens. The hinge of the right valve is preserved only in its anal portion in the case of one full-grown specimen (fig. 10). It exhibits two powerful perfectly horizontal parallel dental ridges, of which the upper one can be followed forward for a distance of 14 mm., while the lower one disappears much sooner. In a specimen whose total length is 55 mm., the groove separating the dental ridges ceases to be distinct after a distance of 9 mm. When followed towards its anterior end, gradually contracting in an oral direction. On the ventral side of the lower horizontal dental ridge; there also occurs one short oblique dental ledge, extending for a total length of 4·5 mm. and separated from the adjacent dental ridge by a dental furrow which becomes gradually contracted as it trends in an oral direction. The flanks of the dental ridges in both valves bear fine crowded transverse wrinkles which are perfectly plainly visible even with the naked eye.

The posterior portion of the shell displays an elongated triangular field slightly excavated in a transverse direction and divided off from the flanks of the shell by means of an edge which trends very obliquely from the umbo towards the lower corner of the shell. This rim which extends downwards with a shallow convexity is very pronounced in the umbonal region where its crest-line is almost rectangular; it gradually flattens out posteriorly. In the case of full-grown specimens the anal portion of the field is almost flat.

The ornamentation of the shell includes both concentric and radial ribs. The concentric costation consists of more or less wide-spaced ribs, which are especially distinct in the middle of the flanks, while they gradually dwindle in an anterior and posterior direction. They usually have more or less the shape of a coil, or else they may be narrower and more or less distinctly roof-shaped and very irregularly spaced, or else they constitute step-like interruptions in the slope of the shell in which case they succeed one another very regularly and at regular intervals. The breadth of the concentric ribs varies considerably: there is every gradation from coils with a breadth of 1·6 mm. down to the finest striations of growth. Many specimens are without any distinct concentric ribs and only exhibit delicate striæ of growth. Near the umbo the concentric ribs are always very fine or totally absent.

The radial ornamentation varies considerably. In all the available specimens the right valve has its ribs distinctly or considerably finer than the left valve, especially in the regions furthest removed from the umbo. In the region of the umbo the ribs almost always exhibit the form of a shallow roof. On the left valve they gradually thicken distally and assume the shape of more or less pronounced coils which are more raised at their intersections with the concentric ribs than in the intervening portions. On both valves the radial ribs attain their maximum thickness in the posterior half of the flanks. Towards the oral side of the shell the intervals between successive ribs become gradually greater, so that the pre-umbonal portion of the flanks usually carries only 3 or 4 wide-spaced ribs. The number of flank-ribs varies in the available specimens from 12 to 16. Alternating with these main ribs, one observes in the case of many of the specimens a set of secondary ribs which disappear in the umbonal region, and are considerably feebler than the main-ribs. There are usually two, or rarely only one of these secondary ribs in each main interval. Occasionally the secondary intervals themselves bear one or two additional ribs which are usually still finer than the secondary ribs, though they are sometimes scarcely feebler. When this happens there may result a system of 5 or 6 fine ribs between every other main rib. This interstitial ornamentation may occur on both valves, yet it is rather exceptional, for the majority of specimens do not exhibit any indication of intercalary ribs between the main ones.

In the triangular field on the post-umbonal part of the shell besides the strongly marked growth striations, one observes only three or four radial ribs which are indeed very feeble and distinctly visible only near the umbo. In an isolated left valve with exceptionally prominent sculpture, these ribs remain distinct up to a distance of 30 mm. from the umbo towards the anal portion. Another isolated left

valve exhibits feeble though distinct secondary ribs in the two lowest interstices of the field.

The species is represented by a number of specimens, some of which are without any record of their origin, while others are labelled "Gieumal," and "Spiti valley" (figs. 3, 6). One of the specimens from the Schlagintweit collection in Munich is labelled "Ki (Spiti)."

Arca Egertoniana is not closely related to any other known species. In many characters it recalls *Cucullæa virgata* Sowerby from Kachh, (*Trans. Geol. Soc. London*, 2d ser., Vol. V, Pl. XXII, fig. 1), and *Cucullæa Lasti* G. Müller (Jura Kreide D. O. Afrika, p. 20, Pl. XVII, fig. 1). Nevertheless it is improbable that there can be any close genetic connection between *A. Egertoniana* and either of these species. The excessive posterior elongation of the shell, its much feebler convexity, the less crowded radial ornamentation, etc. easily distinguish *A. Egertoniana* from either of the above-named species.

According to R. Bullen Newton (*Geol. Mag.*, 1896, p. 294) *Arca Egertoniana* occurs also in Somaliland. The African specimens are said to agree entirely with the Indian ones. According to R. B. Newton and G. C. Crick, it occurs also in Arabia.

Genus: TRIGONIA, Bruguière.

TRIGONIA SPITIENSIS, nov. tp. Pl. XCIX, figs. 5, 6.

Trigonia costata Stoliczka, *Mem. Geol. Surv. Ind.* Vol. V, 1866, p. 90; *non* Sowerby.

The species which belongs to the group of *Tr. costata* is represented by two right valves, unfortunately in a poor state of preservation, which were obtained in Spiti at Gieumal.

The shell is moderately convex and of small size. In one of the specimens the length is 33 mm., the height 29 mm.; in the other these dimensions are respectively 29·5 mm. and 25·5 mm. The shape is broadly triangular. In its upper half the anterior portion of the shell is truncated by an almost perfectly rectilinear margin which trends downwards with a broad curvature into the very shallow convexity of the lower margin. The portion of the ventral margin situated close to the carinal ridge and anteriorly to it exhibits a slight notch in the shape of a shallow re-entering angle.

The short bulky umbo is anteriorly situated and only moderately incurved.

The area is divided off from the flanks by a very prominent marginal carina which exhibits a feeble and regular curvature. This marginal carina becomes thicker distally and bears bulky tubercles greatly elongated in a transverse direction. Their size increases conspicuously as the series is followed downward. These tubercles are more crowded than the concentric ribs ornamenting the flanks, so that in the middle part of the shell three ribs correspond to four tubercles. The flanks bear bulky, concentric, relatively wide-spaced ribs which are only slightly curved and which do not quite reach the marginal carina which is consequently bordered anteriorly by a space bare of ornaments; the width of this space is about 1·3 mm. in the middle portion of the shell. The concentric ribs are almost parallel

with the lines of growth which they distinctly intersect only at their anterior extremity where they trend towards the anterior margin at almost a right angle. The concentric ribs are very crowded in the umbonal region ; as they recede from the umbo the width of the intervals gradually increases and at a distance of 8 mm. from the umbo, the intervals, in the middle of the shell, already amount to 2 mm. The structure of the posterior termination of the concentric ribs is especially interesting. Unfortunately it is observable on only one of the specimens (fig. 6) and even then is not sufficiently perfect to be quite intelligible. Up to a distance of 12·5 mm. from the umbo, the posterior termination of the ribs seems quite rectilinear and they appear to become lost into the bare zone without any change of strucsure. The following rib-termination, at a distance of 14·5 mm. measured along the bare ante-carinal zone, when examined under a suitable illumination already show traces of a feeble dorsally directed inflection, which, in the following rib, becomes already much more distinct. The latter becomes gradually reduced in height and thickness at its extremity, and reaches much further back than the previous ones towards the ante-carinal zone (which, however, is due partly at least to its better state of preservation), and it exhibits a very distinct dorsally directed shallow inflection. The next rib is very badly preserved, though a careful examination still reveals traces of the dorsally directed inflection. The following ribs are not in a sufficiently good state of preservation to afford any further indications in this respect, and this is unfortunately the case with the second specimen also. Nevertheless, these scanty indications lead us to the conclusion that, in all probability, the anal terminations of the ribs exhibited a curvilinear deflection which however is not observable in the upper part of the shell where it probably, in fact, did not exist.

The ornamentation of the area, unfortunately, is observable only in one specimen and even then only in its lateral portions. In the preserved portion it consists of very delicate radial ribs bearing slightly raised crowded granulations. These granulations, and their interspaces, gradually increase slightly in size as they recede from the umbo ; at half the height of the shell there are 7 granulations to an interval of 5 mm., while in the lowest part of the area, the same interval includes only 5. In consequence of the very regular spacing of the granulations, they constitute regular transversal series conforming to the direction of the lines of growth, and trending obliquely inwards and upwards in the form of a slanting trellis. The granulated ribs are very close-set, diverging gradually and regularly in a distal direction. At a distance of 17 mm. from the umbo, measured along the marginal carina, the interval between the fifth and innermost distinct granulated ridge and the crest of the carina is 4·2 mm. this interval being measured along the lines of growth. The interval between the outermost granulated ridge and the crest of the carina is about double that between successive granulated ridges. The hinge and the internal features are not accessible to observation in the available specimens.

This species belongs to a small group of closely related forms represented in India by *Trigonia brevicostata* Kitch., *distincta* Kitch., *dhosœnsis* Kitch., and *nitida*

Kitch., all from the Chari group, and in Australia by *Tr. Moorei* Lyc., while the other Jurassic regions have not yielded, so far, any closely analogous type. From *Trigonia dhosæensis* Kitch., a species of the Upper Chari beds (Jur. Faun. Cutch, Gen. Trigonia, *Pal. Ind.* Ser. IX, Vol. III, Pt. 2, p. 29, Pl. III, figs. 1, 2), *Trigonia spitiensis* is distinguished by its somewhat different shape, much feebler convexity, narrower ante-carinal zone, feebler indentation at the lower margin of the shell, more crowded ornamentation of the marginal carina, apparently still more delicate ornamentation of the area. From the similarly closely related *Tr. brevicostata* Kitch. (*l. c.*, p. 23, Pl. II, figs. 4, 5) from the Lower Chari beds, the Spiti form is distinguished by a somewhat different shape, a much feebler curvature of the concentric ribs, a narrower ante-carinal zone with a smaller indentation at the lower margin of the shell, wider spacing and greater bulk of the tubercles on the marginal carina, and apparently more delicate ornamentation of the area. As regards the ornamentation of the marginal carina, *Tr. spitiensis* occupies an intermediate position between the two species from Kachh.

Genus: ASTARTE, Sowerby.

The Spiti shales exhibit a remarkably rich development of the genus *Astarte* both as regards individuals and species. All the specimens have their shell preserved.

The distribution of the rich material into separate species presents certain difficulties. It appears to me that there are four species readily distinguishable by means of their shape and their degree of convexity. Nevertheless there also occur individuals exhibiting certain intermediate characters.

Two of the species appear to be represented in Kachh by closely-related or identical forms. These are *Astarte Hermanni* which is perhaps identical with *A. unilateralis* Sow. from Kachh and *A. Sowerbyana* which seems very closely related to *A. major* Sow. (*non* Ziet.) also from Kachh. Unfortunately I have not been able to examine any specimens from Kachh and it is impossible to identify the fossils with absolute certainty by means of Sowerby's illustrations and descriptions. The Spiti species of *Astarte* are not clearly related to any extra-Indian forms.

ASTARTE HERMANNI, Oppel. Pl. XCIX, figs. 7-11, 14.

Astarte Hermanni Oppel, Palæont Mitteil., I, 1863, pp. 273, 297[1].

Astarte? *unilateralis* J. de C. Sowerby, *Trans. Geol. Soc. London*, 2nd ser., Vol. V, 1840, Pl. XXI, fig. 14.

Astarte unilateralis Salter *in* Strachey's Pal. of Niti, 1865, p. 97, Pl. 23, fig. 10, *an* Sow.?

Astarte unilateralis Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 90, *an* Sow.?

This species is represented by a large number of specimens. Most of them are without any record of the locality from which they were obtained, but a few are labelled "Chikkim".

[1] The following references probably also apply to this species :—

Unio? and *Trigonia*? Herbert and Everest, *Gleanings in Science*, Vol. III, p. 272, Pl. XVII, fig. 4*a*, *b*, (1831).

Unio? Everest, *Asiat. Research.*, Vol. XVIII, Pt. 2, 1833, p. 114, Pl. II, fig. 26.

Astarte planata Sow. var. J. de C. Sowerby, *Asiat. Research.*, Vol. XVIII, Pt. 2, 1833, p. 278.

Astarte Hermanni is distinguished from all the other species of the Spiti shales by its relative dimensions which are as follows :—

Length.	Height.	Thickness.
37·0 mm.	28·5 mm.	17·0 mm.
34·5 „	29·0 „	16·0 „
40·5 „	31·5 „	17·5 „
43·0 „	29·5 „	19·5 „
49·5 „	37·0 „	23·5 „
51·0 „	39·0 „	24·0 „

The shell is greatly elongated in an anal direction, and very convex. The faithful illustrations give an excellent idea of its outline. A flank view of most of the specimens reveals a characteristic posterior wedge-like contraction of the shell which is either absent or at least less pronounced in all the other *Astarte* species of the Spiti shales. The straight ligamental margin is connected by means of a very shallow curvature with the anal margin. The anal margin in its dorsal portion displays generally a very shallow curvature, while its ventral portion is nearly always much more convex, and unites by means of a continuous curve with the shallow arc-shaped trend of the ventral margin. The anterior margin in its ventral half forms a fairly prominent convexity, while in the region of the lunula it is excavated by a shallow concavity. The umbo is situated in the anterior part of the shell; it projects only slightly beyond the cardinal margin. At the apex of the umbo the marginal limbs of the lunula and area converge at an angle of 100° to 120° which is rounded off only at its extreme summit. The medial surface of the umbo slopes inwards almost vertically. In the case of well-preserved full-grown specimens, the interval between the umbonal apices of opposite valves is about 1 mm.

The elongated ligamental area extends for nearly two-thirds of the entire length of the shell. Its greatest breadth coincides with the middle of its course or is situated slightly anteriorly to it, while it contracts gradually and regularly in an anterior and posterior direction. In the case of one specimen, whose total length is 49·5 mm., the area has a length of 32·5 mm. and a maximum breadth of 7·5 mm. In another specimen with a length of 37 mm., the area has a length of 24 mm. and a breadth 5·8 mm. The ligament is sunken into the anterior part of the area; in all the available specimens, it either does not reach the middle of the area in an anal direction, or only just oversteps it. On either side of the ligament, the floor of the area rises outward. The surfaces of both halves of the area are perfectly plane and their angle of slope is very feeble at the anal end of the ligament while it becomes gradually steeper towards the umbo. Beyond the anal extremity of the ligament, the slope continues to flatten out gradually till the two halves of the area come to assume an approximately or completely horizontal position. The left half of the area is always situated a little higher than the right one, because the left cardinal margin always slightly overlaps the right one. Near the umbo the area is bounded by a sharp edge which gradually becomes truncated as it trends in an anal direction, until it becomes very much rounded off. Internally to this marginal rim

there follows a very narrow marginal zone which slopes inwards at a somewhat steeper angle than the medially sloping floor of the area and is divided off from it by an obtuse re-entering angle. It is only in the immediate neighbourhood of the umbo that, in consequence of the steep slope of both halves of the area, this marginal zone ceases to be appreciable. This steeply sloping marginal zone is distinctly developed on the right valve up to the extreme posterior end on the area or nearly so, its breadth, at its posterior end, amounting to about 1 mm. in the case of full-grown specimens. This feature constantly shows a somewhat different development in the case of the left valve. The marginal rim in the left valve constitutes a distinct edge only for a short distance from the umbo; as it trends anally it becomes much more rounded off than in the right valve. The steep marginal zone adjacent to the rim is distinctly visible only along the proximal half of the area in the left valve of full-grown specimens and becomes completely obliterated in an anal direction, so that the horizontal floor of the posterior portion of the area merges directly by means of a shallow curvature into the flanks of the valve, while on the right valve the flat surface is bordered externally by the sloping marginal zone.

The shape of the lunula is more or less broadly oval with upper and lower pointed terminations. Its inner portion appears but slightly concave both in a dorso-ventral and medio-lateral direction. In the neighbourhood of the umbo the lunula is bordered by a sharp angular edge which ventrally gives place to a shallow curvature. This marginal rim of the lunula varies considerably. In several specimens the marginal rim trends obliquely downwards in an almost rectilinear course for 8 mm. from the umbo, and, throughout this distance it has the form of a sharply angular edge; in its further course it suddenly assumes a gradual curvature towards a medio-ventral direction, and its crest becomes greatly truncated. In other specimens the marginal rim of the lunula exhibits a more or less pronounced and often somewhat irregular curvature even in its uppermost portion and does not become distinctly sharply angular except quite close to the umbo, while ventrally it becomes quite rounded off. Between these two extremes one observes every intermediate gradation.

The ornamentation consists of concentric ribs which, in the umbonal region of well-preserved specimens, are always sharply angular and keel-shaped and are disposed at approximately regular, gradually increasing intervals. In a ventral direction, and at a varying distance from the umbo, these ribs gradually assume the character of flat, shallow folds, disposed at irregular intervals and irregularly alternating in their amount of relief, sometimes even becoming completely obliterated and replaced by irregular more or less distinct striations of growth. Amongst the available specimens, the sharp angular concentric ribs extend at most to a distance of about 12 mm. from the umbo; in certain specimens this character subsists only to a distance of some 4 mm. from the umbo, beyond which there follows an unornamented zone some 4 or 5 mm. broad bearing nothing but some excessively delicate striations of growth: this form of ornamentation is also

observed in certain specimens of *A. spitiensis* Stol. (see Pl. C, fig. 7a).[1] The ornamentation does not extend over the floor of either the lunula or the area, as it becomes obliterated on reaching their outer margins. Near the umbo where the rim of the lunula and area assumes the form of an angular edge, the ribs are suddenly interrupted on reaching the angular margin. Where the rim is rounded instead of angular, the concentric sculpture oversteps its border and, in the right valve, reaches medially as far as the indentation formed by the junction of the narrow steeply sloping marginal zone with the floor of the area. In the left valve the ornamentation also oversteps the crest of the marginal rim.

The hinge is not visible in any of the specimens, though it probably agrees with that of *A. spitiensis*. The inner margins of the valve are serrated throughout their whole extent with the exception of the cardinal margin. The serrations are very strongly developed along the ventral margin: in those specimens where it is most pronounced there are about 9 teeth to an interval of 10 mm. Dorsally the serrations gradually become much finer.

ASTARTE SOWERBYANA, nov. sp. Pl. XCIX, figs. 12, 13, 15; Pl. C, fig. 1.

? *Astarte major* J. de C. Sowerby, *Trans. Geol. Soc. London*, 2nd ser., Vol. V, 1840, Pl. 61, fig. 1; *non* Ziethen, Verst. Württemberg.

? *Astarte major* H. F. Blanford, *Journ. As. Soc. Bengal*, XXXII, 1863, p. 134, *an* Sow.?

Astarte major Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 91, *an* Sow.?

This form is extraordinarily similar to *Astarte Hermanni* from which it is distinguished merely by its different degree of convexity and the difference in shape of the shell. The convexity of *A. Sowerbyana* is feebler, and the shell is much more elongated anally than in the case of *A. Hermanni*. The following dimensions were measured on various specimens:—

Length.	Height.	Thickness.
40·0 mm.	30·0 mm.	16·0 mm.
48·0 „	36·0 „	17·5 „
48·5 „	36·5 „	? „ [2]
55·0 „	41·0 „	21·0 „
57·5 „	42·5 „	? „ [2]

In most specimens the characteristic feature of the outline is the merging of the anal margin together with the dorsal and ventral margins into one continuous strongly convex curve. The wedge-shaped contraction that characterises the posterior contour of the shell in *A. Hermanni* is much less pronounced. In every other particular the fossil agrees exactly with *A. Hermanni* with which it is no doubt closely related genetically. The specimen represented in fig. 12 is in many respects intermediate between both species. The hinge is visible in the case of the left valve represented in Pl. XCIX, fig. 13. In all essential characteristics it agrees with that of *A. spitiensis* Stol. described below.

[1] This disposition is correctly shown only in fig. 7*a*; figs. 7*b* and *c* fail to give so correct an impression of the appearance of the costation in the umbonal region.

[2] The specimen is flattened out.

Some of the specimens of *Astarte Sowerbyana* are from Kibber and Chikkim; the remainder are without any record of their occurrence.

Astarte scytalis, nov. sp. Pl. C, figs. 2, 3.

This species is represented by two specimens without any exact record of their origin. They are distinguished from *A. Sowerbyana* owing to their much more pronounced convexity and at the same time their more elongated shape. From *A. Hermanni* with which they agree as regards the degree of convexity, they are conspicuously distinguished by their much more elongated shape which gives them a very distinct appearance. The dimensions of the two specimens are as follows:—

Length.	Height.	Thickness.
50 mm	35 mm.	22·5 mm.
51 „	36 „	24·5 „

The anal margin is either perfectly regularly rounded and connected by a continuous curve with the dorsal and ventral margins, or else it exhibits an increase of convexity both in its lower half and at its junction with the dorsal margin. The lunula is much more deeply concave than in the foregoing species. In every other visible character the fossil agrees exactly with *A. Hermanni* and *A. Sowerbyana*.

Astarte spitiensis, Stoliczka. Pl. C, figs. 4-8.

Astarte spitiensis Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 91, Pl. IX, fig. 9.
Astarte hiemalis Stoliczka, *l. c.*, p. 91, Pl. IX, figs. 2, 3.

Astarte spitiensis agrees closely with *A. Sowerbyana* as regards the convexity of the shell, but is nevertheless distinguished from all the preceding forms owing to its different outline. The shell appears decidedly higher than in the case of the foregoing species, which produces the effect of communicating to it an unusually rounded outline. The relatively strongly arched ventral margin is connected by a very regular curvature with the oral margin and with the strongly convex regularly curved anal margin, the latter passing into the dorsal margin, usually by means of a shallow curvature, or, rarely, through a somewhat more decided convexity. The dimensions of a series of specimens are as follows:—

Length.	Height.	Thickness.
41·0 mm.	34·0 mm.	17·5 mm.
44·0 „	35·0 „	? „ [1]
57·0 „	49·5 „	*circa* 22·5 „ [1]
57·5 „	50·5 „	23·5 „

[1] The specimen is flattened out.

As regards the sculpturing of the shell, and also the features of the area and lunula, the form exhibits the same variations as *A. Hermanni*.

The structure of the hinge is accessible to observation in several specimens. The left valve exhibits two large cardinal teeth directed very obliquely backwards and enclosing a deep socket in which fits the unusually large posterior cardinal tooth of the right valve. The small anterior cardinal tooth of the right valve consists of a rounded or only slightly elongated protuberance and corresponds in the left valve, with a moderately deep socket bordered, towards the oral margin, by an inconspicuous rounded, extremely flat, sometimes scarcely appreciable lateral tooth. Posteriorly the hinge region of the left valve exhibits, immediately below its upper margin, a relatively shallow uniformly depressed furrow, not reaching nearly so far back as the area, and terminating, towards the umbo, on a level with the posterior part of the ligament, into which fits a flat lateral tooth of the right valve.

I have examined the original type-specimen of Stoliczka's *A. spitiensis*. The triangular shape which this specimen exhibits, and which Stoliczka considered to be the most important character of his species, clearly results from the mode of preservation of the specimen, the lower margin of which is damaged by a fracture of considerable extent. The course of the lines of growth indicates that the specimen must have exhibited originally a rounded outline.

A. hiemalis Stol. was established upon an immature specimen of *A. spitiensis*. The type-specimen, which I have had re-figured in Pl. 100, fig. 6, is characterised by very closely packed concentric ridges. The specimen also exhibits the interior of the shell: the muscular impressions are of oval outline, the anterior impression being distinctly smaller and decidedly deeper than the posterior one. The pallial line is not distinctly shown.

The exact locality of the specimens has not been recorded.

Genus: Pleuromya, Ag.

Pleuromya spitiensis, nov. sp. Pl. XCIV, fig. 4.

The solitary specimen bears the following label: "Upper Spiti shales (Etage III), Lochambelkichak E. G." It is in the state of an internal cast, a considerable portion of which still carries the extremely thin inner shelly layer, while only a very small fraction still bears a remnant of the middle shelly layer which is also thin though distinctly thicker than the inner layer.

The shell, as may be seen from the full-size illustration, is of moderate dimensions, conspicuously inflated, very inequilateral, greatly elongated in an anal direction. The dorsal margin is almost all broken. The posterior margin exhibits a shallow convexity and merges with a shallow curve into the very feebly and continuously arched ventral margin. The anterior margin is broken.

The umbo is bulky, obliquely deflected inwards and forwards. Its apex is not visible. In a flank view of the shell the dorsal outline of the umbo appears rather

broadly truncated by a somewhat oblique, very shallow curve. When the shell is viewed anteriorly a considerable portion of the dorsal surface of the umbo is observed to slope medially at a rather steep angle.

An exceedingly shallow rounded, feebly indicated edge trends obliquely backwards and outwards from the umbo, with a very feeble curvature and is lost before reaching the anterior third of the post-umbonal portion of the shell. When the shell is viewed dorsally, this edge appears to diverge from the ligament margin at an angle of 35° to 40°.

The anterior portion of the shell shows a broad flat lunula divided off from the flanks by means of a very distinct edge, whose course is fairly strongly curvilinear and whose crest is rounded-truncate. The maximum breadth of the lunula is 14·5 mm. Its ventral portion is unfortunately broken. About the middle of each of the two halves of the lunula there is an exceedingly shallow, truncated, rounded, radial edge, disappearing in the neighbourhood of the umbo, by the intervention of which the inner part of the lunula with its gentle medially directed slope, is divided off from the almost flat marginal zone which slopes gently outward. At about half the height of the shell this marginal zone has a breadth of 4 mm.; it contracts rapidly and regularly towards the umbo. The illustrations do not convey a very distinct idea of the appearance of the lunula, and in fig. 4*a* in particular, its laterally sloping marginal zone appears much too broad.

The ornamentation consists of coarse, irregular striations of growth. With the help of a strong magnifying glass, the excessively thin innermost shelly layer, where best preserved, exhibits a punctate appearance due to the presence of excessively delicate fairly thickly crowded, raised granulations.

The outline of this species recalls the form figured by Müller as *Pl.* cf. *peregrina*, (Jura u. Kreide D. O. Afrikas, p. 14, Pl. XVI, figs. 3, 4). It also recalls certain specimens of *Pl. varians* Ag. from the Upper Jurassic of Europe.

Genus: Cosmomya, nov. gen.

Cosmomya egregia, nov. sp. Pl. XCIV, fig. 3.

An isolated cast of a left valve, showing the typical mode of preservation of the fossils from the Spiti shales, exhibits such exceptional characters that it cannot find its place in any hitherto known genus. I have found it necessary therefore to institute for it a new genus for which I propose the name Cosmomya. The specimen is a cast without any trace of the original shelly substance. The ornamentation is very distinct, and yet there are no indications of the muscular scars: both these circumstances by their simultaneous occurrence indicate that the original shell must have been extremely thin. This feature, taken in conjunction with the other characters, such as the general shape, the anterior position of the inward incurved umbo, and the ornamentation which finds its closest analogy in the genus *Ceromya*,

make it seem most probable that *Cosmomya* should be included within the group of the Myarians.

Unfortunately the margins of the solitary specimen are broken throughout their whole extent. The shell is fairly strongly and regularly convex both in a dorso-ventral and oro-anal direction. The region of greatest convexity is situated along a zone which trends at an angle of about 45° from the umbo towards the ventro-anal part of the shell. The umbo is short, conically pointed at its extremity, its point being rounded off only at its extreme end. It is conspicuously flattened in a dorso-ventral direction; it trends inwards almost horizontally. It points somewhat obliquely inwards and forwards, and its terminal portion is slightly deflected downwards. Its ventral surface, which has the appearance of a vertically situated hollowed-out groove gradually flattening out in an anal direction, is divided off from the adjacent portion of the dorsal surface of the umbo by means of a blunt edge which trends almost horizontally, and which very soon ceases to be distinct in the pre-umbonal part of the shell, but which can be followed with gradually decreasing relief, to a considerable distance from the umbo on its anal side. Laterally from this edge, and diverging from it at a very acute angle, there is a very shallow furrow which trends from the apex of the umbo, and which gradually broadens out somewhat in an anal direction, following a flat arched curvilinear course in an oblique and backward direction. At a distance of 23 mm. from the umbo it gradually disappears. The ornamented part of the flanks is divided off by means of this furrow from a triangular unornamented area which gradually broadens out in an anal direction. In the immediate neighbourhood of the umbo this area slopes almost perpendicularly inwards. With increasing distance it undergoes a gradual reversal of its direction of slope, so that at 9 mm., from the umbo it is nearly horizontal, and further along in an anal direction it slopes outward with increasing steepness.

The ornamentation is particularly interesting. It consists of a series of excentrically disposed ribs, very delicate and crowded in the neighbourhood of the umbo, while distally their width and spacing gradually increase. In section they are feebly arched. They are separated by narrow shallow intervals. Throughout the greater part of the shell these intervals are much narrower than the adjacent ribs: on an average they are smaller by about one-third. The ribs trend obliquely from anteriorly downwards to posteriorly upwards. Along a line which trends along the flanks almost vertically down from the umbo (line of inflection) there occurs a perturbation of their course which, near the umbo takes the shape of a slight transient interruption, but further away appears as a double inflection; some of the ribs are totally obliterated at the line of inflection and do not reappear along the post-umbonal part of the shell. In an oral direction the ribs disappear before reaching the anterior margin, which leaves an intervening unornamented marginal zone. At 7 mm. from the umbo, this marginal zone already attains a width of 3 mm. The ribs situated nearest the umbo are moderately curvilinear and trend obliquely backwards and upwards almost from their anterior extremity with increasing steepness. Those situated further from the umbo exhibit a distinct

ventrally directed trend at their most anterior portion, beyond which, with a moderate curvature, they gradually bend round till they assume an ascending direction. Up to a distance of 9·5 mm. measured along the line of inflection, the ribs nearest the umbo exhibit, along this line of inflection, a different disposition from the ventrally succeeding ones: they do not display any distinct inflection, but only a very slight interruption, so that the branch situated beyond the inflection line actually follows in the same direction as the pre-umbonal part. The ventrally succeeding ribs exhibit, along the line of inflection, a pronounced double bend so that the portion situated behind the inflection is displaced in a ventro-anal direction. The two branches of the disjointed rib are connected by a short oblique rib directed backwards and downwards, which is scarcely 1 mm. long at the uppermost part of the double-inflected ribs; distally the connecting ribs gradually increase in length, so that the one whose termination is situated at 25 mm. from the umbo already has a length of 3 mm. At the lower point of inflection the ribs do not exhibit any interruption or even weakening; indeed some of them even display an appreciable thickening. At the upper point of inflection, on the other hand, the ribs, for a short distance are interrupted or at least conspicuously depressed, so that the anterior points of inflection succeed one another in the form of a very narrow shallow groove. Beyond the zone of inflection the ribs travel upwards with a feeble curvature and at a very steep angle, until their thickness, together with the width of the intervals, becomes reduced to one-fifth or one-sixth of the maximum. They disappear immediately before reaching the marginal furrow of the area. Indeed this regular disposition of the post-umbonal portion is observed only in the neighbourhood of the umbo, up to a distance of 11 mm. measured along the marginal furrow. The posteriorly succeeding ribs exhibit quite a different disposition. At a certain distance from the marginal furrow, these ribs exhibit a remarkable perturbation of their course in the shape of several irregular undulating inflections. At the first of the ribs affected by this disturbance, the distorted portion is only of small size and causes an anally directed shifting of the distal rib portion of about 3 mm. The space thus left free is occupied by two short intercalary ribs ending abruptly downwards. The succeeding ribs exhibit successively increasing disturbances and display a four-fold inflection which brings about an irregular zig-zag disposition of the ribs in that part of the shell and, in some places, causes an appreciable broadening of the interspaces. The interspaces following the fourth rib beyond the commencement of the perturbation exhibit this widening not only along the zone of disturbance, but also throughout their downward course where they become as wide or wider than the intervening ribs; the latter are in places slightly wavy. At their dorsal end these disturbed ribs, with the exception of the first and second, are appreciably diverted backward. The third disturbed rib is extremely weakened at its dorsal termination which is not parallel with that of the preceding one, but is diverted backward, so that if it were prolonged up to the marginal furrow it would meet it at a right angle. The succeeding ribs conform to this one. All the ribs do not extend uninterruptedly from the pre-umbonal to the

post-umbonal part of the shell: on an average every third rib stops at the line of inflection, at a level with the upper point of inflection, beyond which it does not reappear. Counting from the uppermost distinctly visible rib which reaches the line of inflection at 4 mm. from the umbonal apex, it is the second, sixth, twelfth, sixteenth, nineteenth and twenty-second on the pre-umbonal side which end abruptly at the line of inflection. All the others extend over the post-umbonal part.

The lines of growth are very delicate and feeble and are entirely absent from the upper third of the shell nearest the umbo.

It is impossible to discuss exhaustively the exact systematic position of the genus, since it is represented by an incomplete specimen, and the hinge, in particular, remains unknown. That it belongs to the Myarians seems quite beyond a doubt, and within this group, it is principally with *Ceromya* that the details of the ornamentation indicate a relationship. Indeed a simple deflection of the ribs is observed in several species of *Ceromya* situated along a line trending from the umbo downwards and the characteristic undulating course of the ribs in the dorso-anal region is also observed in some species of *Ceromya*. The divergence in the shape of the shell and especially the invariably inflated umbo of *Ceromya* easily distinguish it from the Indian genus.

The above described specimen bears the following label: "Geode in black shales below Werfen beds; fossil doubtful, but there are no Spiti shales south of the Niti Pass. N. W. Kimplong, S. W. Niti Pass." The specimen shows unmistakably the mode of fossilisation characterising the Spiti shales. Besides this specimen there is also a small fragment preserved as a cast in the same matrix as a specimen of *Oppelia acuticincta* Strach.

Genus: Homomya, Ag.

Homomya tibetica, Stoliczka. Pl. XCIV, fig. 1.

Homomya tibetica Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 92, Pl. IX, fig. 4.

This species is represented by a solitary specimen illustrated in the above-mentioned figure. It bears the label "Gieumal." It is in the condition of a rather poorly preserved cast.

As shown by the illustration, it is large, moderately inflated, very inequilateral, greatly elongated anally. The dorsal margin is preserved only in its post-umbonal portion where it is nearly rectilinear throughout almost its whole extent. The posterior margin projects backwards with a moderately strong convexity. It is connected by a very shallow curve with the dorsal margin, and passes gradually downwards into the ventral margin. The anterior margin is broken.

The shell is posteriorly gaping. On the dorsal side[1] the shell margins are in contact up to a distance of about 24 mm., beyond which they diverge rather

[1] The dorsal margin is not quite intact and has been greatly idealised in the picture. The artist has made the separation of the margins extend too far forward.

widely in an anal direction and reach their maximum interval of about 10·5 mm. in the middle of the anal margin. Unfortunately the margins in this part of the shell are not well preserved.

The umbo of the internal cast is broad and depressed, moderately bent inward in a horizontal direction. In a flank view of the shell the dorsal contour of the umbo exhibits a broad, flat convexity. Viewed anteriorly the dorsal surface of the umbo appears to slope medially at a moderately steep angle and with a very shallow convexity for a distance of about 4 mm.

In a dorsal view of the shell, one observes an edge trending in an anal direction from the umbonal apex, with a very flat arch-shaped curvature and diverging feebly from the ligament margin. It ceases to be perceptible at about 16 mm. from the umbo and is, at that place, distant from the ligament margin by about 5·2 mm. The interval between this edge and the ligament margin, is, on the internal cast, transversely excavated. A very much rounded edge proceeds also anteriorly from the umbo. It is preserved only in its posterior portion where it is almost rectilinear; its anterior portion is injured and cannot be distinctly observed. The illustration in this part of the shell has been far too much idealised : the pre-umbonal edge is not in any way distinctly recognizable beyond a distance of 9 mm. from the umbo. The pre-umbonal part of the dorsal margin is also entirely broken and should not have been represented in the illustration.

With regard to the outer surface of the cast, the appearance conveyed by the illustration is far too smooth : it is much roughened by weathering and it is only in the neighbourhood of the ventral margin that it shows two very shallow, rather narrow lines of growth. The pallial line is not visible.

The extreme elongation of the shell recalls *Homomya gracilis* from the upper Jurassic (Oxfordian, Portlandian) of Switzerland (Agassiz, Mon. des Myes, p. 162, Pl. XX, figs. 1-3, and de Loriol, L'Oxford. du Jura bernois, p. 66, Pl. XI, fig. 1).

Genus : Goniomya, Agassiz.

Goniomya Uhligi, nov. sp. Pl. XCIV, fig. 2.

This species is represented by a single specimen of an inner cast exhibiting the typical mode of preservation of the Spiti shales.

It is unfortunately very badly preserved as it lacks not only the anterior and inferior margins, but also all the anal part of the shell. The shape is fairly strongly convex. The upper margin is almost rectilinear on the posterior side of the umbo. The umbo is flat and depressed and only slightly deflected inwards. The ornamentation consists of angular ribs such as characterise the genus *Goniomya*. Near the umbo these ribs are weak and very crowded. They are somewhat better developed on the right valve than on the left one. With increasing distance from the umbo, the intervals between the ribs widen considerably and the ribs themselves become stronger. Owing to the poor state of preservation of the umbonal part of the shell,

the disposition of the ribs situated nearest the umbo is not clearly recognisable. The marginally succeeding ribs exhibit a very sharp inflection dividing the ribs into an anterior and posterior branch. The points of inflection are disposed along an almost straight line of inflection which trends obliquely backwards and downwards from the umbo, and diverges from the upper margin at an angle of about 65°. The intervals between two successive ribs do not remain of uniform breadth throughout their course. The maximum breadth is situated in the lower part of the posterior portion, while the breadth, throughout the anterior branch, is much feebler : even at its lowermost end, it is, in some extreme cases, less than a third of the width of the corresponding posterior portion, and the ribs trend still closer together in an anterior direction. In the posterior section, the ribs remain parallel for a considerable distance away from the point of inflection, beyond which, as they approach the dorsal margin, they gradually come much closer together, so that, at their distal extremity, the intervals between the ribs are scarcely wider than the ribs themselves. As the ribs succeed one another marginally, their spacing gradually increases as is shown by the following figures expressing the breadth of successive intervals measured on the left valve along the zone of maximum spacing, that is at the lower end of the posterior section of the ribs. Beyond the rib whose point of inflection is situated at 16 mm. from the umbo, the ribs follow at intervals of 3·5, 4, 4·6, and 5 mm. between each other ; in all parts of the flanks the successive intervals exhibit similar differences in the distribution of their relative breadth. It is seen from these figures that the increase of breadth is not quite regular.

In the pre-umbonal part of the shell the ribs are almost parallel with the striations of growth. After an extensive concentric course they bend downwards at a rounded obtuse angle slightly before reaching the line of inflection. The downward deflected portion of the anterior section attains a length of 10 mm. in the case of one of the ribs of the left valve whose point of inflection is situated at 26 mm. from the umbonal apex and it diverges from the orally directed portion at an angle of about 150°. The inflection of the ribs of the left valve forms an angle of about 85°. Posteriorly to the point of inflection, the ribs of the left valve ascend at a very steep angle and remain almost rectilinear and parallel to one another for a considerable distance. At about half the distance between the point of inflection of each successive rib and the dorsal margin, the posterior branches of the ribs exhibit a flattened curvature beyond which they trend obliquely upward and forward with a slight curvature, and gradually converge closer to one another. The uppermost anal termination of one of the ribs, whose point of inflection is situated at 26 mm. from the umbonal apex, converges at an angle of 130° with the upper margin which it does not quite reach. The anally following ribs become more and more oblique to the upper margin, while on the oral side, the direction becomes less oblique and gradually approaches a right angle. The rib whose point of inflection is situated at 26 mm. from the umbo is the only one on the left valve whose entire course is visible. The ribs situated between this one and the umbo appear to agree with it in every detail. The one situated next to it more marginally exhibits certain differ-

ences: it disappears suddenly at the place where it should first be deflected downwards, but its posterior continuation reappears at about 5 mm. in a dorsal direction from the place where its inflection ought to have been. The next rib towards the margin is very indistinct in its pre-umbonal portion; the lower end of its posterior branch is at 9·5 mm. from the place where its inflection point ought to have been. It seems therefore that, in the lower part of the shell, there is a broad zone corresponding with the continuation of the zone of inflection, along which the ornamentation becomes completely obliterated.

The costation of the right valve differs in many respects from that of the left. Unfortunately in this valve also there is only one single rib that can be recognised throughout its entire extent. Its pre-umbonal portion is at first almost concentric with the lines of growth; it already becomes deflected downwards at 13·5 mm. from the point of inflection at an angle of about 140°. The point of inflection is displaced much further downwards than in the left valve. The lower part of the posterior branch is not quite rectilinear as in the left valve, but is strongly curved downwards at its lowermost extremity so that the junction of the two branches is situated much deeper than in the left valve and the two branches converge at an angle of about 45°. In the other portions of its course it agrees exactly with the rib-features of the left valve. The next rib marginally following the one just described is obliterated along the zone of inflection in the same way that characterises the left valve. The anterior branch of this rib approaches within about 1 mm. of the deflected portion of the preceding rib and disappears there; at about 5 mm. before reaching the place where it disappears, it exhibits a very slight downward deflection. The posterior section of this rib fades away in a ventral direction without reaching the point of inflection, and remains rectilinear up to the place where it disappears. The anterior section of the next following rib also exhibits an extremely slight and local downward deflection at 7 mm. from its point of interruption; the point where it disappears is scarcely deeper than the point of inflection of the last of the uninterrupted ribs and is situated at 6 mm. from it.

In a dorsal direction the flank-ribs in the post-umbonal part of the shell extend as far as a very shallow almost rectilinear sub-marginal furrow which trends somewhat obliquely backwards from the umbo; at 30 mm. from the umbo this furrow is 5 mm. distant from the upper margin of the shell and has a breadth of 1·8 mm. Proximally it gradually contracts and almost disappears at 5 mm. from the umbo. The furrow is succeeded in a median direction by an elongated swelling which bears an irregular tuberculated ornamentation. At the proximal end of the swelling, up to a distance of 18 mm. from the umbo, the very flat tubercles are disposed along the continuation of the flank ribs; distally there are only a few very shallow protuberances which no longer correspond with the ribs.

The striations of growth are distinctly visible only in the lower portion of the shell which still bears many remnants of the shelly layer. In the pre-umbonal part of the shell the lines of growth extend backwards and downwards with a gentle curve and reach the deepest point of their curvature before reaching the line of inflection.

The disposition of the striations of growth indicates that the shell was conspicuously elongated in an anal direction, and exhibited somewhat the same elongated shape as *Gon. constricta* Ag.

The peculiar ornamentation of *Gon. Uhligi* gives it a very isolated position amongst all other species of the genus.

The specimen is labelled: "Geode in black shales below Werfen beds; doubtful on account of fossil—N. W. Kimplong, S. W. Niti Pass." The characteristic mode of preservation establishes beyond doubt that it belongs to the Spiti shales.

Genus : PHOLADOMYA, Sowerby.

PHOLADOMYA ? PROBLEMATICA, nov. sp. Pl. XCVIII, fig. 16.

This remarkable fossil is represented by a solitary very imperfect cast which is shown in full-size in the above-mentioned illustrations. It was obtained between Chota Hoti and Ting Jung La in Hundes.

It seems equivalve, somewhat inequilateral, only slightly deflected obliquely in its posterior portion, strongly inflated, extraordinarily compressed in an oro-anal direction. The margins are broken with the exception of a short very feebly curvilinear fragment of the posterior margin. The umbo is also broken. In a dorso-ventral direction the shell is strongly and fairly regularly convex. In an oro-anal direction it is extraordinarily strongly convex, a considerable portion of the anterior and posterior regions of the shell is nearly flat and disposed almost perpendicularly to the median plane of the mussel. The crest zone is very convex and the crest-line is situated a great deal to the oral side of the deepest point of the lines of growth.

The original shell was extremely thin. It is observable at a few places where the cast is still partly embedded in the original matrix. The cast is ornamented with delicate, somewhat irregular inconspicuous lines of growth. They are rather too pronounced as shown in fig. 16*a*. with a suitable incidence of the rays of illumination, one may just distinguish, with the unaided eye, along the crest zone, traces of delicate, crowded very shallow radial striations which disappear near the umbo and towards the lower margin.

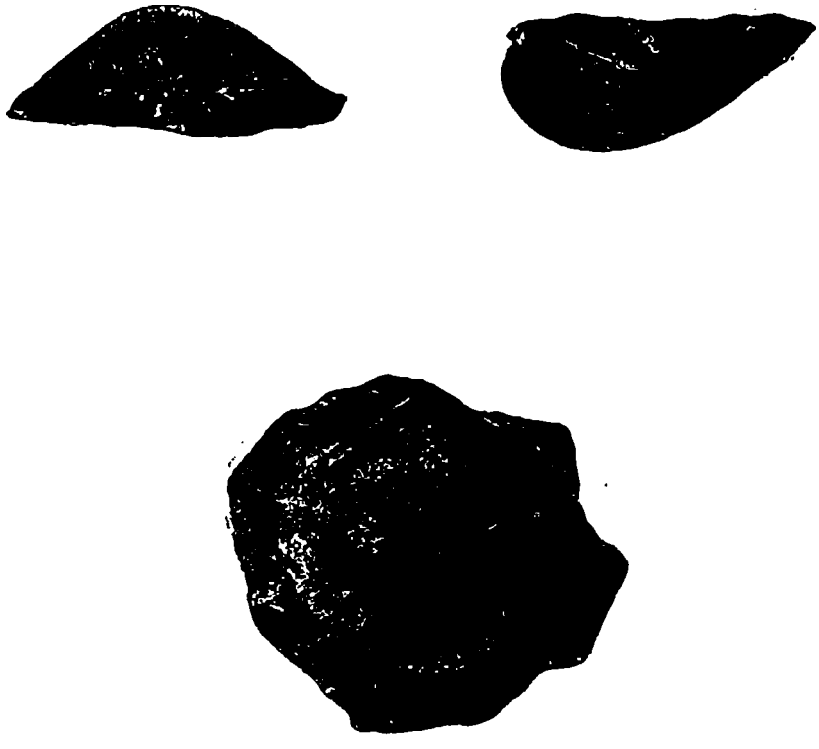
The generic attribution of this remarkable form is uncertain, yet it most probably does belong to the genus *Pholadomya*. I am not acquainted with any Jurassic forms resembling this fossil.

Genus: INDET.

The following illustration represents an internal cast which cannot be generically determined. The solitary specimen bears the label: "Upper Spiti shales, Etage III, Lochambelkichak E. G."

The shell is very slightly though distinctly oblique. Since this oblique elongation, in the great majority of inequilateral bivalves, affects the posterior side of the shell, the present specimen probably represents a right valve.

Its dimensions are shown in the full-size illustration. The shell is rather strongly inflated, and strongly and regularly convex. Its margins are not quite intact. The ventral margin combines with the oral and anal margins to constitute a continuous curve approximating in shape to three quarters of a circle. The dorsal margin is imperfectly preserved and not completely exposed. It does not show any trace of cardinal teeth or of an external ligament. There are no ears.



Genus indet. Natural size.

The umbo is situated somewhat anteriorly to the middle of the total length. It is very small, and strongly compressed dorso-ventrally. Its terminal part is not visible; it does not seem involute. When the shell is viewed anteriorly, the dorsal surface of the umbo appears to slope medially at a shallow angle and with a shallow curvature for a distance of 4·5 mm.

The ornamentation of the cast is restricted to some inconspicuous, somewhat irregular lines of growth. The shell seems to have been excessively thin. The muscular scars and pallial line are not visible.

GASTROPODA.

The Gastropod fauna of the Spiti shales includes only three badly preserved species of which *Cerithium* sp. belongs to the Belemnite Beds, while the two other forms were obtained from the Spiti shales proper.

Genus: Pleurotomaria, Defrance.

Pleurotomaria spitiensis, nov. sp. Pl. XCIV, figs. 5-8.

Pleurotomaria sp ? H. F. Blanford, *Journ. As. Soc., Bengal*, XXXII. 1863, p. 134, Pl. IV, figs. 3, 3*a*.
Pleurotomaria sp. Stoliczka, *Mem. Geol. Surv. Ind.*, Vol. V, 1866, p. 92.

This form is represented by a number of specimens which I have united into one species in spite of certain differences which they exhibit. The specimens are either entirely in the condition of casts, or else they present only feeble remains of the shell. Some of the specimens are from Kibber (fig. 6), others from Gieumal (fig. 8); others are without any record of their origin (figs. 5, 7).

The cast has a tall conical shape including about three volutions, in the case of well-preserved specimens. The volutions increase rapidly and regularly in size, and are separated from one another by deeply impressed sutures. The volutions are transversely strongly convex and, with the exception of the apical whorl, carry a pronounced rounded spiral edge whose position approximately corresponds with that of the sinus-band. On the last whorl of the cast, this sinus-edge is situated very distinctly higher than the middle of the whorl: on the penultimate whorl it lies at about the middle of the visible portion. On the last whorl of the cast, the sinus-edge is always very pronounced: it exhibits the form of an obtuse edge truncated by a curvature only at its extreme crest. As the edge is followed towards the apex of the spire, it becomes gradually more rounded and loses indistinctness, until all trace of it is lost in the apical volution whose surface is regularly convex. In the case of the largest specimen which is represented in fig. 6, the sinus-edge, in the neighbourhood of the mouth of the shell, is 12·5 mm. distant from the suture of the last whorl. The portion of the whorl situated posteriorly to the sinus-edge exhibits transversely an excessively depressed and regular convexity, or else it is quite flat, or even, in one specimen (fig. 7) it distinctly exhibits a very shallow concavity. This same portion of the shell, that is the zone between the sinus-edge and the posteriorly situated suture, carries on the last whorl of one specimen, a very shallow rounded edge which already ceases to be perceptible on the penultimate volution. There is no trace of this subsidiary edge on any other specimen.

The well-preserved casts invariably carry another very blunt spiral edge situated anteriorly to the sinus-edge and at some distance from it. In several specimens (fig. 7 *a*, *c*) this swelling is very conspicuous on the final whorl, but loses in distinctness on the penultimate one. In other casts (fig. 5, for instance) it is much less distinct or almost missing, and can be made out only under a suitable illumination. The zone intervening between this swelling and the sinus-edge is almost flat. In this manner a very indistinct lateral band is produced which is gradually lost in the apical portion of the cast. In the case of the largest available specimen (fig. 6), this lateral band, in the neighbourhood of the mouth, attains a breadth of 7·2 mm. In the last whorl of the specimen represented in fig. 7, the width of the lateral band is 5·5 mm. On the penultimate whorl, the anterior

margin of the lateral band is situated quite close to the suture. On the cast the lateral band slopes fairly distinctly towards the axis of the shell.

The base, anteriorly to the lateral band of the last whorl, is usually moderately and regularly convex, and quite smooth. In the solitary case of the specimen illustrated in fig. 7, the cast exhibits anteriorly to the anterior margin of the lateral band, three more very blunt edges distributed at fairly wide intervals. A fourth ridge is also faintly indicated. This portion of the shell is always concealed on the penultimate whorl.

Beyond the above described edges, the casts do not show any other ornament. Only fragmentary remnants of the thick shell subsists on a few specimens (figs. 6. 8), and they do not convey any information regarding the ornamentation of the outer surface. The sinus-ridge appears to have been very pronounced.

Pleurotomaria spitiensis is very variable in size. The largest specimen is represented full-size in fig. 6. The smallest specimen is scarcely half as tall, though it also consists of about three volutions.

Genus : Cerithium, Bruguière.

Cerithium sp. Pl. XCIV, fig. 10.

This form is represented only by the figured specimen, the shell of which is preserved. It bears the following label "Lower Spiti shales, Kuti." (Coll. F. H. Smith).

The condition of the specimen is very unsatisfactory. The ornamentation of the surface is very poorly preserved. The few observable characters are shown on the illustration.

Undeterminable form. Pl. XCIV, fig. 9.

This is a very badly preserved cast from Jandu in Hundes. The few visible characters are shown in the illustration. The external impression of the shell surface does not show any ornaments.

PLATE XCIV.

Fig. 1. HOMOMYA TIBETICA, Stoliczka.
„ 2. GONIOMYA UHLIGI, n. sp.
„ 3. COSMOMYA EGREGIA, nov. gen., n. sp.
„ 4. PLEUROMYA SPITIENSIS, n. sp.
Figs. 5-8. PLEUROTOMARIA SPITIENSIS, n. sp.
Fig. 9. Undeterminable form.
„ 10. CERITHIUM sp.

All the figures are drawn in natural size.
The original specimens are in the Calcutta Museum.
The localities of the specimens, so far as is known, are mentioned in the descriptive text.

JURASSIC FOSSILS (HIMALAYA)

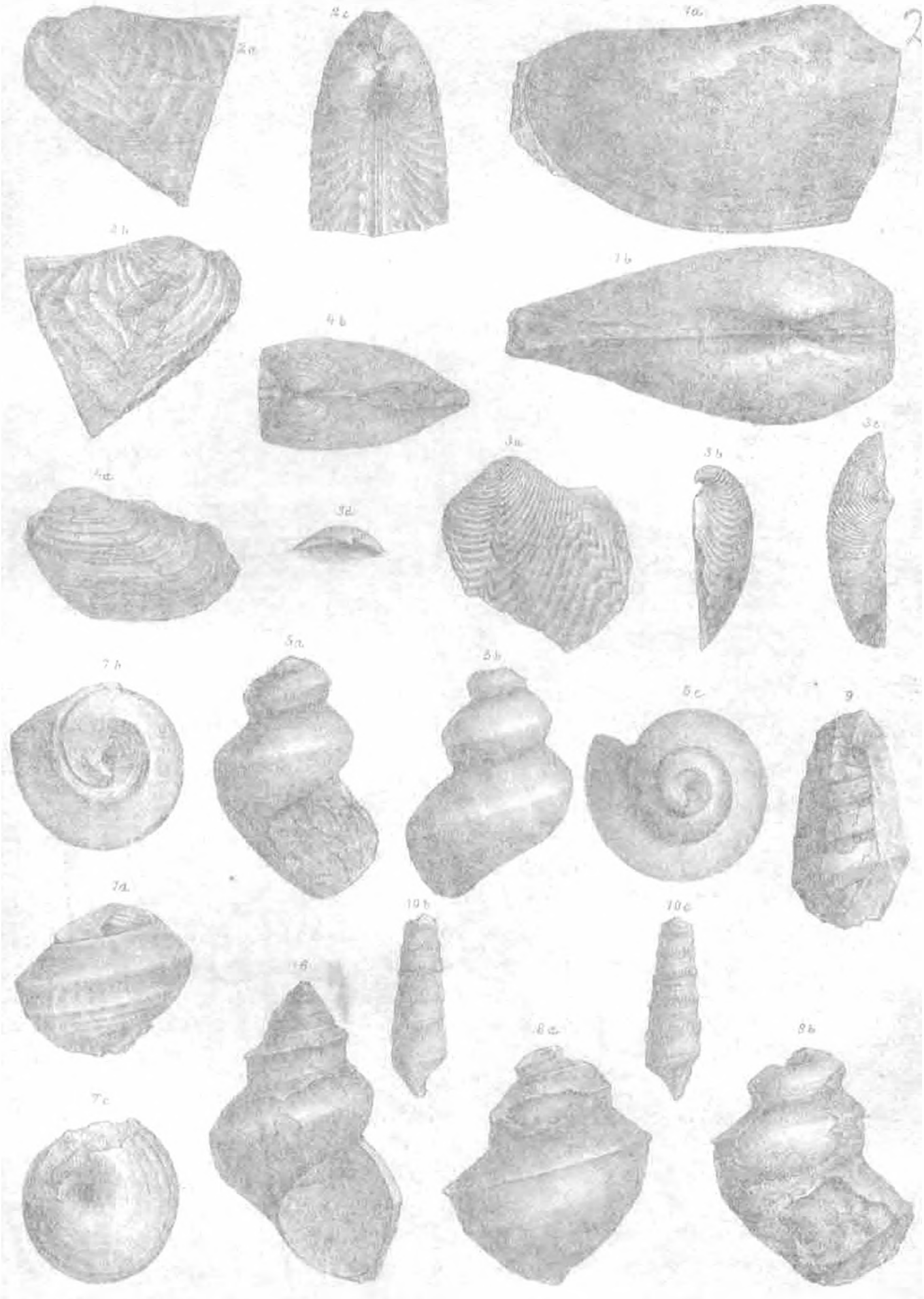


PLATE XCV.

Figs. 1-10. ARCA EGERTONIANA, Stoliczka.
„ 11-13. NUCULA SPITIENSIS, n. sp.
„ 14-17. „ HYOMORPHA, n. sp.

Figs. 1*d*, 2*d*, 2*e*, 3*c*, 6*b*, 9 and 10 are enlarged. All the others are drawn in natural size.
The original specimens are in the Calcutta Museum.
The localities of the specimens, so far as is known, are mentioned in the descriptive text.

JURASSIC FOSSILS (HIMALAYA).

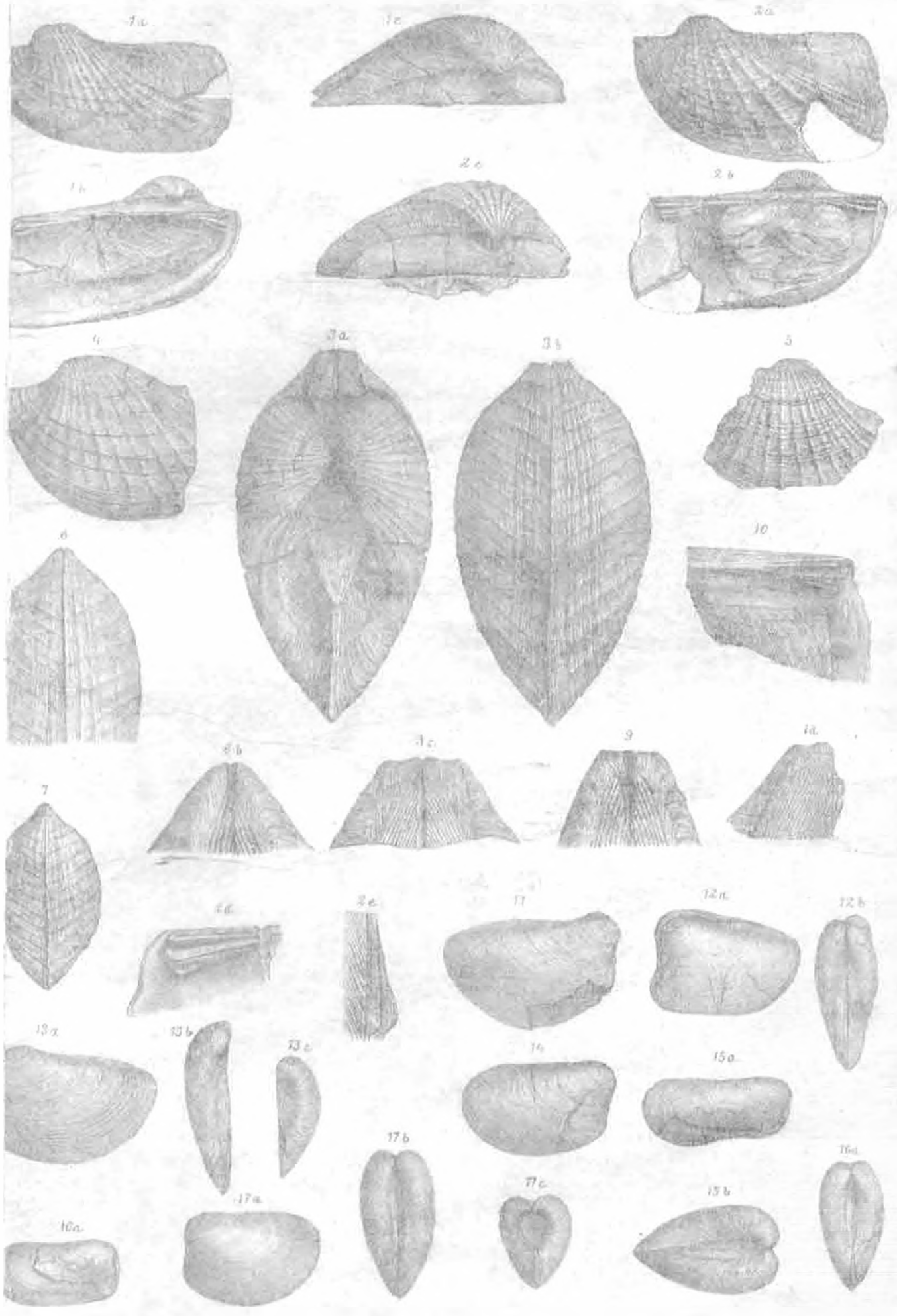


PLATE XCVI.

Figs. 1, 2. LIMA SPITIENSIS, n. sp.
Fig. 3. „ ROBERTI, Oppel.
„ 4. „ MELANCHOLICA, n. sp.
„ 5. „ TRISTICULA, n. sp.
„ 6. PECTEN, sp.
„ 7. „ INERTULUS, n. sp.
„ 8. OSTREA, sp.

Figs. 3*b* and 5 are enlarged. All the others are drawn in natural size. The original of fig. 3 is in the Museum at Munich. All the others are in the Calcutta Museum.

The localities of the specimens, so far as is known, are mentioned in the descriptive text.

The figured species of Ostrea probably does not belong to the Spiti shales.

Pl. XCVI

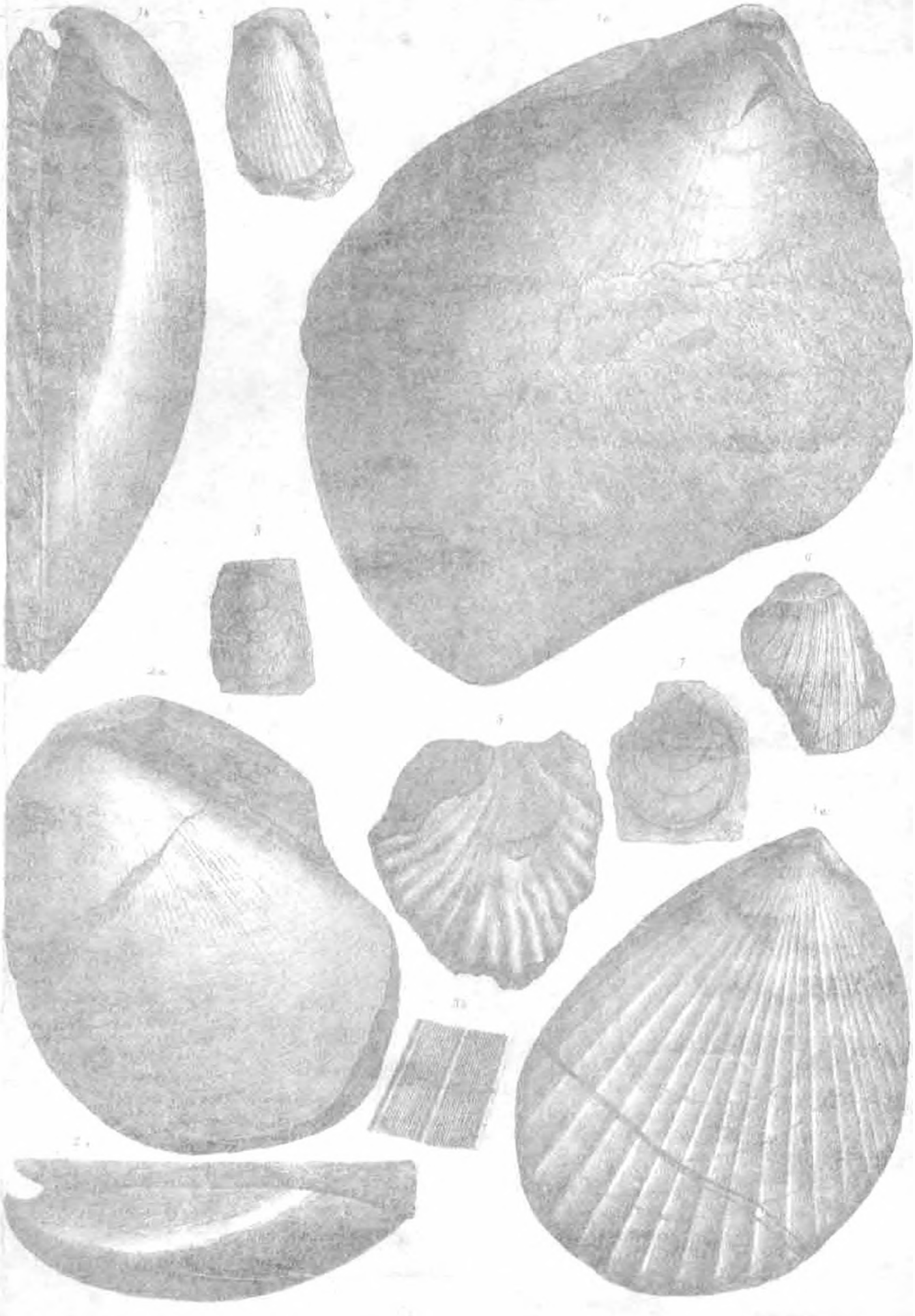


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PLATE XCVII.

Fig. 1. AVICULA SPITIENSIS, Oppel.
Figs. 2, 3. PSEUDOMONOTIS INORNATA, n. sp.
Fig. 4. „ AMŒNA, n. sp.
„ 5. AUCELLA LEGUMINOSA, Stoliczka.
„ 6. „ ? FORMOSA, n. sp.
„ 7. „ SPITIENSIS GRANDIS, nov. form.
Figs. 8-11. „ „ n. sp., form. typ.
Fig. 12. „ „ EXTENSA, nov. form.
„ 13. „ „ SUPERBA, nov. form.

Figs. 2*d* and 4*c* are slightly enlarged. All the others are drawn in natural size.

The original specimens of figs. 1, 3, and 8 are in the Museum at Munich. Fig. 13 is fr a plaster cast of a specimen in the British Museum. All the other specimens are in the Calcu Museum.

The localities of the specimens, so far as is known, are mentioned in the descriptive text.

JURASSIC FOSSILS (HIMALAYA).

Fleischmann n. d. Nat. in Stein. mpz.

PLATE XCVIII.

Figs. 1-9. AUCELLA BLANFORDIANA, Stoliczka.
„ 10-11. INOCERAMUS STOLICZKAI, n. sp.
„ 12-14. „ EVERESTI, Oppel.
Fig. 15. „ GRACILIS, n. sp.
„ 16. PHOLADOMYA? PROBLEMATICA, n. sp.

All the figures are drawn in natural size.

The original specimens are in the Calcutta Museum.

The localities of the specimens, so far as is known, are mentioned in the descriptive text.

PLATE XCIX.

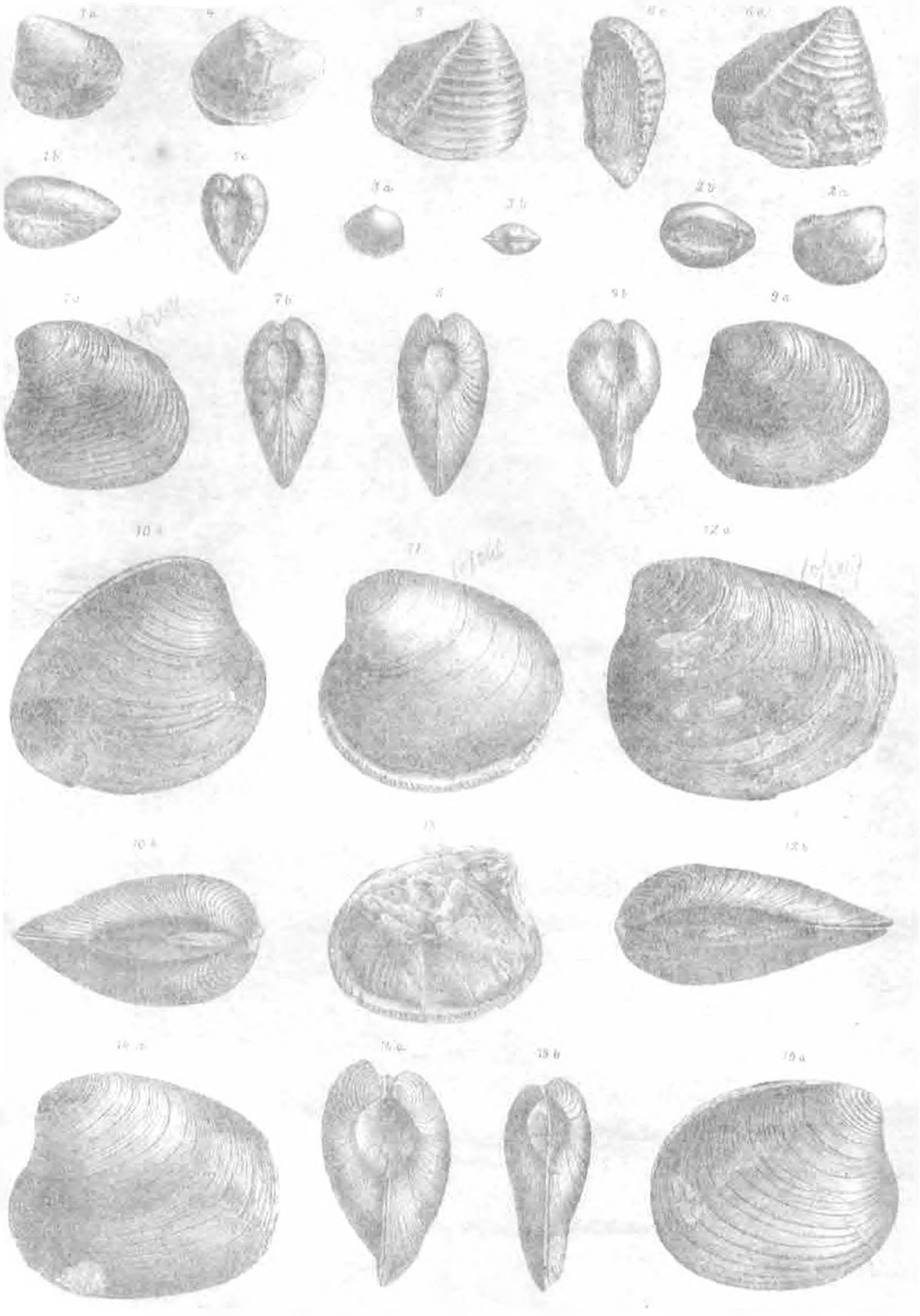
Fig. 1. NUCULA KIBBERIANA, n. sp.
„ 2. „ sp. (cast).
„ 3. „ DIENERI, n. sp.
„ 4. LEDA sp.
Figs. 5-6. TRIGONIA SPITIENSIS, n. sp.
„ 7-11,14. ASTARTE HERMANNI, Oppel.
„ 12,13,15. ASTARTE SOWERBYANA, nom. nov.

All the figures are drawn in natural size.

The original specimens are in the Calcutta Museum.

The localities of the specimens, so far as is known, are mentioned in the descriptive text.

JURASSIC FOSSILS (HIMALAYA)



Albert Berger print

PLATE C.

Fig. 1. ASTARTE SOWERBYANA, nom. nov.
Figs. 2-3. „ SCYTALIS, n. sp.
„ 4-8. „ SPITIENSIS, Stoliczka.

All the figures are drawn in natural size.

The original specimens are in the Calcutta Museum.

The localities of the specimens, so far as is known, are mentioned in the descriptive text.

JURASSIC FOSSILS (HIMALAYA).