PALÆONTOLOGICAL NOTES ON THE LOWER TRIAS OF THE HIMALAYAS, *by* C. L. GRIESBACH, F. G. S., *Geological Survey of India.*

Major-General R. Strachey, R.E., C.S.I., was the first to notice and describe[1] some of the grand sections through the Himalayas, and to draw attention to the existence in these snowy regions of triassic strata closely allied (as E. Suess has first shown)[2] to the Trias of the Eastern or Austrian Alps. As it has been my good fortune to have been sent to these lofty regions, I must here acknowledge the debt we owe to the learned General for having furnished such an excellent basis for further research in the most interesting region of the globe.

Having mapped the snowy ranges between the valleys of the Dhauli Ganga and Gori Ganga (Niti and Milam), I was able to collect a considerable material for description, but I must defer the detailed report on these noble sections, with maps, until after the next field season, when I hope to extend the survey to the frontiers of Nepál.

The great anticlinal fold of porphyritic gneiss with granite, termed by Stoliczka "Central gneiss" (by way of comparison with the so called "Central gneiss" of the Alps, a definition which has been given up long ago), is conformably overlaid by various metamorphic schists[3] and these again by the Palæozoic and following formations, a brief description of which I have given in the companion paper in this number of the Records. I will therefore only mention that on the eroded surface of the carboniferous rises the huge mass of the triassic and Rhætic strata. The Rhætic beds form high, nearly perpendicular cliffs with an undercliff of older rocks, comprising the whole Trias from the Alpine Werfen beds (Buntsandstein) to the Upper Keuper rocks, all of which are well shown in the natural profile of Plate IV; the proportions of thicknesses and the outlines of the cliff are absolutely correct, being drawn with the aid of a camera lucida, from an opposite height, about in a horizontal plain with the junction of the Rhætic and Trias.

In the following list I give a detailed enumeration of the beds composing both the Rhætic and the Trias, with their probable correlations:—

Upper Oolite (Spiti shales).

		THICKNESS. Ft.	In.
Lower Lias ... Resembles the Grestener beds of the Eastern Alps.	1. Black shales and dark earthy limestone with oolitic structure, containing ... ... *Belemnites bisulcatus*, Stol. " *tibeticus*, " " sp. *Ammonites annulatus*, Sow. var. " *davsei*, Sow. *Rhynchonella austriaca*, Sss. *Thalassites depressus*, Qu. *Ostrea*, sp. *Pecten*, sp.	13	0
	Total ...	13	0

[1] Quart. Jour. Geol. Soc., Vol. VII, p. 292.

[2] Verh. Geol. Reichsanst. 1862, p. 258.

[3] *See* Text illustration, fig. 1, of my paper in this number of the Records, p. 84.

		THICKNESS. Ft.	In.
Rhætic ...	1. Grey crinoid limestone, very hard, weathering brown, thick-bedded, with intercalated shales, full of fossils, and in many places made up entirely of them. Containing a mixture of true Rhætic and Liassic forms:	13	0
Represents the Starhemberg facies of Kössen beds of the Alps.	*Pecten bifrons*, Salt.		
	„ *mayeri*, Winkl. (var.)		
	„ *lens*, Sow.		
	„ *corneus*, Gldfss. (non Sow.)		
	„ *cornatus*, Mün.		
	„ *valoniensis*, Defr.		
	Gervillia inflata, Schfl.		
	Plagiostoma herrmanni, Qu.		
	„ *giganteum*, Qu.		
	Pholadomya roemeri, Ag.		
	Myophoria cardissoides, Schl.		
	Cardium rhæticum, Mer.		
	Terebratula horia, Sss.		
	Rhynchonella fissicostata, Sss.		
Hauptlithodendron-limestone of Suess:	2. Grey *Lithodendron* limestone shewing sections of small shells on weathered surfaces	6	0
	3. Grey limestone with fossils as bed 1, and *Lithodendron*	5	0
with Kössen beds in following.	4. Dark grey sandstone-like crinoid limestone with numerous white calcspar veins	9	6
	5. Uneven shaly beds similar to (4)	3	0
	6. Dark grey crinoid limestone alternating with shaly beds	17	0
	7. Grey massive crinoid limestone	17	0
	8. Sandstone-like limestone, false-bedded, here and there shaly	2	0
	9. Dark brecciated limestone with crinoids ...	1	6
	10. Very hard grey crinoid limestone with *Lithodendron*	5	6
	11. Flaggy beds of crinoid limestone	2	3
	12. Brecciated bed, made up of angular pieces of dark limestone with a few rounded pebbles; thins out rapidly	0	8
	13. Crinoid limestone, locally as (12)	3	0
	14. Dark crinoid limestone in irregular beds with white calcspar veins	13	0
	15. Grey dolomitic limestone in beds of about 1½″ alternating with papery shales	2	6
	16. Dark grey sandstone-like crinoid limestone, top beds, shaly towards base, in thick masses ...	16	0
	17. Dark grey flaggy limestone (unfossiliferous) in beds of about 2″ to 5″, with shaly partings ...	7	0
	18. Brown shaly sandstone thinning out ...	0	5
	19. Flaggy limestone, vertically jointed ...	9	3
	20. Uneven sandstone bed } with thin shaly partings.	0	6
	21. Grey calcareous sandstone } with thin shaly partings.	0	6
	22. Grey limestone } with thin shaly partings.	0	9
	23. Grey calcareous sandstone } with thin shaly partings.	0	6

		Thickness. Ft.	In.
	24. Grey limestone flags with shaly partings ...	2	0
	25. „ friable shales	0	6
	26. „ limestone	0	9
	27. Friable grey needle-shales	0	2
	28. Grey limestone in massive beds with a few thin partings of shales	7	0
	29. Dark grey needle-shales, thin out and pass into limestone	1	2
	30. Thin flaggy limestone beds	0	6
	31. Dolomitic limestone	0	8
	32. Shaly limestone	2	4
	33. Crinoid limestone with some fossils (Kössen type)	1	0
	34. Sandy shales	1	8
	35. Crinoid limestone	0	5
	36. Papery sandy shales	0	2
	37. Brown calcareous sandstone (fossils)	0	7
	38. Crinoid limestone	0	4
	39. Shaly „	1	2
	40. „ and papery calcareous beds	1	3
	41. Grey limestone	0	3
	42. Sandy shales	0	3½
	43. Crinoid limestone	1	0
	44. Papery calcareous shales	0	2½
	45. Sandstone shales	0	5
	46. Shaly crinoid limestone	0	8
	47. „ and flaggy crinoid limestone	2	0
	48. Grey calcareous sandstone	0	4
	49. Shales	0	2
	50. Grey crinoid limestone	0	7
	51. Sandy shales	0	5
	52. Papery marly shales	0	10
	53. Grey limestone with shaly partings	0	10½
	54. Friable limestone shales	1	0
	55. Marly bed	0	8
	56. Irregular bed of grey limestone; thins out ...	1	3
	57. Flaggy limestone with shales	6	9
	58. Grey crinoid limestone with *Belemnites* ...	0	5
	59. Limestone flags with friable shales	4	0
	60. Crinoid limestone with *Pecten bifrons*, Salt ...	1	4
	61. Limestone flags and shales	2	4
	62. Shaly calcareous sandstone	2	9
	63. Crinoid limestone with a shaly parting ...	1	9
	64. „ „ with *Pecten bifrons*, Salt ...	3	0
	65. Dark limestone alternating with shaly crinoid beds	4	0
	66. „ grey limestone, dolomitic, with shaly partings	35	0
	67. „ fossiliferous crinoid limestone in massive beds	45	0
Dachstein limestone.	68. Grey earthy limestone full of *Myacites* sp. ...	7	0
	69. Hard limestone beds, containing many fossils, and on the weathered surfaces showing sections of large *Megalodon* sp.	35	0

		Thickness. Ft.	Thickness. In.
	70. Hard crinoid limestone in thicker beds ...	7	6
	71. Dolomitic limestone	6	0
	72. „ „ in flaggy beds	3	6
	73. Massive grey dolomite, towards base rather flaggy	45	0
Hauptdolomit ...	74. „ dolomite, with scarcely any bedding ...	135	0
	75. As (74), but with partings of crinoid limestone ...	223	0
	76. Dolomite in beds of about 4 feet thickness towards base, reddish, and containing *Lithodendron* ...	98	0
	77. Dark concretionary limestone with reddish purple cellular Rauchwacke appearance here and there, in beds of 6 inches to 1 foot	5	0
	78. Crinoid limestone in thicker beds	11	0
Plattenkalk of Gümbel.	79. Dark dolomites in massive beds, the contact surfaces knitted together (resembling sutures, in the outcrop)	100	0
	80. Dolomites and limestone beds with "knitted" contact surfaces as (79), full of *Lithodendron*, and with a few shaly partings	48	0
	81. Massive beds of dark blue limestone and dolomite alternating with flaggy beds of limestone; the latter form about 12 feet of the upper part. Some masses of it of dark purple colour with crinoid sections	50	0
	82. Dark dolomites with calcspar veins	147	0
	83. „ „ flaggy beds and partings of shaly sandstone	241	0
	84. Dark hard concretionary limestone alternating with dolomitic beds	74	0
	85. Grey and reddish dolomites in perfectly inaccessible cliffs, about	700	0
	TOTAL ...	2,200	7½

As I intend to give here only a short description of the lowest members of the Trias, I will only say so much, that in the main the above Rhætic section corresponds exactly with the typical sections of that formation in the Austrian Alps, namely, we have here in descending order:—

1. Lithodendron-limestone, interbedded with limestone containing fossils belonging to the Alpine Kössen beds, which have been grouped into four horizons by Suess=Hauptlithodendronkalk with Kössen beds.
2. Thick-bedded limestones, here and there dolomitic, still with Lithodendrons here and there, and beds with Megalodon=Dachsteinkalk.
3. Great development of dolomites and flaggy limestones=Hauptdolomit with Gümbel's Plattenkalk.

The undercliff consists of a series of beds which represent the whole of the marine Trias beds of the Eastern Alps. The series rests on the denuded and rugged carboniferous quartzites, which again form a steep cliff falling almost vertically down to the base of the valley.

The detailed section of it is as follows :—

	UPPER TRIAS.	THICKNESS. Ft.	In.
Alps : ... Opponitzer beds.	22. Compact brown (liver-coloured) limestone, with rough contact surfaces; beds nearly of equal thickness, about 12 inches, and here and there separated by greenish-grey shales. Numerous bivalves, closely allied to	152	0
	Corbis mellingi, Hau. var.		
	21. Liver-coloured brown limestone, alternating with greyish-green shales, containing	29	0
	Corbis mellingi, Hau. var. *Orthoceras*, sp.		
	20. Earthy limestone with shaly partings ...	228	0
	19. Shaly limestone with earthy shales alternating ...	30	0
Alps :	*Spirifer lilangensis*, Stol. var.		
Lunzer and Partnach beds.	18. Shaly limestone and shales with hard concretionary limestone	22	0
	17. Greenish-grey shales	4	6
	16. Limestone with chert nodules	1	6
	15. Flaggy limestone	5	0
	14. Friable greenish-grey shales, weathering brown, with flaggy limestone alternating ...	31	0
	13. Marly friable shales	5	0
Alps : ...	12. Hard grey limestone	4	0
Hallstadt beds.	11. Hard grey limestone, weathering brown, rather silicious, containing nodules of white concretions with fossils : *Opis globata*, Dtm. *Aorochordiceras spinescens*, Hau. *Tropites ehrlichi*, Hau. var. *Feistmanteli*, n. sp. *Balatonites himalayanus*, Blfd.		
Alps : ... St. Cassian.	10. Grey earthy limestone beds, with marly and shaly partings, weathers brown.		
	9. Same as (10) with *Spirigera*, sp.		
	9, 10, and 11, total	275	0
	8. Greyish-green micaceous shales, a few plant impressions	160	0
	7. Shaly grey earthy limestone	38	0
Alps : ... Wengen beds and St. Cassian.	6. Dark splintery limestone flags with dolomitic beds and very scarce partings of black shales ...	76	0
	5. Black limestone beds in flags of about 6 inches thickness, which form groups of about 3 feet thickness, alternating with the same thickness of black splintery shales, with	152	0
	a species of the group of the *Amaltheidæ* *Halobia rarestriata*, Mojs. *Daonella tyrolensis*, Mojs. " sp.		

		Thickness. Ft.	In.
	4. Dolomitic limestones in more massive beds, with few shaly partings	38	0
Alps : ... Wengen beds.	3. Shaly limestone with— ... ... *Daonella*, sp. *Spirifer lilangensis*, Stol. var.	38	0
	2. Thick-bedded shaly limestone with traces of fossils, mostly Ammonites	48	0
Alps : ... Buchenstein beds.	1. Black limestone flags of about 12 inches thickness, each alternating with black splintery shales of same thickness	103	0

LOWER TRIAS.

			Ft.	In.
II. VIRGLORIA LIMESTONE.	*b.* Reifling limestone (Alps).	122. Very hard grey concretionary limestone in massive beds with subordinate partings of dark shales containing many fossils very difficult to extract: about	50	0
		Orthoceras dubium, Hau. *Trachyceras voiti*, Opp. " *thuilleri*, Opp. " sp. *Arcestes diffissus*, Hau. *Ptychites gerardi*, Blfd. *Pinacoceras floridum*, Wulf. *Pecten*, sp. *Myoconcha*, sp. *Pleurotoma sterilis*, Stol. *Reptilian bones.*		
	a. Recoaro-limestone (Alps).	121. Earthy-grey limestone, towards base somewhat shaly :	3	0
		Rhynchonella semiplecta, Mün., var. } in great numbers. " *salteriana*, Stol. }		
I. WERFEN BEDS	*b.* Campiler beds ... (Alps).	120. Hard grey splintery limestone ...	0	8
		119. Dark friable clayshales, weathering variegated	0	3
		118. Limestone	0	4
		117. Limestone with shaly partings ...	1	6
		116. Limestone	0	1
		115. Shales	2	0
		114. Limestone	0	7
		113. Shales alternating with 12 thin beds of limestone	1	0
		112. Limestone	0	6
		111. Shales	0	4
		110. Limestone	0	3½
		109. Shales with limestone partings ...	1	2
		108. Limestone	0	6
		107. Shales, alternating with 11 limestone partings	2 2	0

			Thickness. Ft.	In.
		106. Limestone	0	8
		105. Shales	0	10
		104. Limestone	0	6
		103. Shales with 5 limestone partings ...	0	11
		102. Limestone	0	5
		101. Shales	0	7
		100. Limestone	0	7½
		99. Shales	0	6
		98. Limestone	0	7
		97. Shales and limestone partings ...	1	2
		96. Limestone	0	8
		95. Shales	0	7
		94. Limestone	0	4
		93. Shales	0	7
		92. Limestone	0	9
		91. Shale with 10 limestone partings ...	1	4
		90. Limestone	0	7
	Salt-range :	89. Shales and limestone partings ...	0	10
	Zone of *N. planulatus*,	*Norites planulatus*, DeKon.		
	DeKon.	88. Limestone	0	6
		87. Shales with limestone parting ...	0	1
		86. Limestone	0	2
		85. Shales with 2 limestone partings ...	0	8
		84. Limestone	0	5
		83. Shales	0	3
I. Werfen beds. —*contd.*		82. Limestone with one shaly parting ...	0	4
		81. Shales with two limestone partings	0	6
		80. Limestone	0	3
		Monophyllites wetsoni, Opp.		
		79. Shales	0	5
		78. Limestone	0	5
		77. Limestone with three shaly partings	0	6
		76. Limestone	0	5
		75. Limestones with 17 shaly partings	1	7
		74. Shales	0	2
		73. Limestone	0	6
		72. Shales	0	½
		71. Limestone	0	2
	Salt-range: zone of	70. Shales with	0	1½
	Ophiceras lyellianum, DeKon.	*Ophiceras tibeticum*, n.s.		
		69. Limestone...	0	½
		68. Shales	0	2
		67. Limestone	0	1
		66. Shales	0	1
		65. Limestone...	0	1
		64. Shales	0	1
		63. Limestone	0	4
		62. Shales	0	½
		61. Limestone	0	1
		60. Shales	0	2
		59. Limestone	0	3
		58. Limestone with 6 shaly partings ...	0	6

		Thickness. Ft.	In.
I. Werfen beds.—*contd.*	57. Limestone	0	2
	56. Shaly limestone	0	1½
	55. Shales	0	1
	54. Limestone with 2 shaly partings ...	0	5
	53. Limestone with shales	0	3
	52. Limestone	0	5
	51. Shales	0	½
	50. Limestone	0	1
	49. Shales and limestone	0	2½
	48. Shales	0	2½
	47. Limestone	0	3
	46. Shales	0	2
	45. Limestone	0	2½
	44. Shales	0	1
	43. Limestone	0	3
	42. Shales with a thin bed of limestone	0	5
	41. Limestone with 9 shaly partings ...	1	3
	40. Limestone	0	1
	39. Limestone	0	3
	38. Limestone with 14 shaly partings ...	1	2
	37. Limestone	0	2½
	36. Shales	0	2
	35. Limestone with shaly partings ...	0	3½
	34. Shales	0	1
	33. Limestone with 3 shaly partings ...	0	5
	32. Shales	0	2
	31. Limestone	0	2
	30. Shales	0	3
	29. Limestone	0	2½
	28. Shales	0	2
	27. Limestone	0	1½
	26. Shales	0	1½
	25. Limestone	0	1
	24. Shales	0	1½
	23. Limestone	0	2
	22. Shales	1	0
	21. Limestone	0	3
	20. Shales	0	1
	19. Limestone	0	3
	18. Shales	0	4
	17. Limestone	0	3
	16. Shales	0	10
	15. Limestone with shaly partings ...	1	6
	14. Limestone	0	6
	13. Shales	1	0
	12. Limestone	0	3½
	11. Shales with 11 thin layers of hard splintery limestone ...	0	4½
	10. Limestone	0	3
	9. Shales with limestone (1") towards top with— *Otoceras woodwardi*, n.s.	5	0

			Thickness. Ft.	In.
I. Werfen beds.—*concld.*		8. Limestone	0	2
		7. Shales	0	5½
		6. Limestone with— ... ... *Xenodiscus gangeticus*, DeKon. „ *buchianus*, „	0	3
	Salt-range, zone of *Ptychites lawrencianus*, DeKon. *Xenodiscus demissus.* „ *gangeticus.*	5. Variegated papery shales ...	0	6
		4. Limestone with— ... ... *Avicula venetiana*, Hau. *Myophoria ovata*, Br. *Posidonomya angusta*, Hau. *Otoceras woodwardi*, n.s. *Xenodiscus demissus*, Opp. „ *gangeticus*, DeKon.	0	4
		3. Friable, papery shales with a parting of limestone (1″) with— ... *Otoceras woodwardi*, n.s.	0	9
	b. Campiler beds ... (Alps).	2. Dark grey limestone with shaly layers with— ... ... *Posidonomya angusta*, Hau. *Gervillia mytiloides*, Schlot. *Modiola triquetra*, Seeb. *Myophoria ovata*, Gdfss. *Avicula venetiana*, Hau. *Bellerophon*, sp. *Nautilus brahmanicus*, n.s. *Otoceras woodwardi*, n.s. „ „ var. *undulatum*, n.s. *Ptychites lawrencianus*, DeKon. *Ophiceras medium*, n.s. „ *himalayense*, n.s. „ *tibeticum*, n.s. „ *densitesta*, Waag., var. *Xenodiscus gangeticus*, DeKon. „ *buchianus*, „ „ *demissus*, Opp. *Trachyceras gibbosum*, n.s.	0	5
	a. Seiss beds (Alps) Salt-range Productus beds.	1. Dark, carbonaceous, crumbling shales, micaceous, weathering in reddish and deep-brown tints, giving it a variegated appearance, with a few thin beds of hard grey limestone. The general character of these shales is the same as of all the intercalated beds of shales of the beds above ... It yielded— *Monotis claræ*, Emmr. *Productus latirostratus*, Howse, var. *Arcestes* sp.	127½	

The whole rests on the carboniferous series.

The above list of beds, it will be seen, corresponds in a marvellous degree with the beds of the Trias as developed in the Eastern Alps, and the order stands therefore as follows :—

The Trias in the Himalayas.

	Character of rocks.	Zones.	Correlation with horizons in the Eastern Alps.	Trias in Germany.
UPPER TRIAS.	6. Liver-coloured limestone with greenish shales.	*Corbis mellingi*, Hau. var.	Opponitz and Raibl.	Keuper.
	5. Friable shales and earthy beds.	*Spir. lilangensis*, Stol.		
	4. Limestone .	*Tropites ehrlichi* .	Hallstadt and	
	3. Earthy beds and shales	......	St. Cassian.	
	2. Black limestone and dolomites.	*Daonella tyrolensis*, Mojs.	Wengen.	
	1. Black limestone flags and splintery shales.	Brachiopods . .	Buchenstein.	
LOWER TRIAS.	4. Hard grey concretionary limestone.	*Ptychites gerardi*, Blfd.	Reifling limestone. } Virgloria limestone	Muschelkalk.
	3. Earthy limestone .	*Rhynchonella semiplecta*, Mün., var.	Recoaro limestone.	
	2. Limestone and shales.	*Posidonomya angusta*, Hau.	Campiler beds } Werfen beds.	Buntsandstein.
	1. Dark shales, etc. .	*Monotis claræ*, Emm.	Beds of Seiss	

As far as is known at present, this succession of horizon holds good in India over a considerable area, to judge from certain beds, which have been found in other parts of our Himalayas. The lower group has been described by Stoliczka from the north-west Himalayas (Spiti), but he considered only the upper part of the Lower Trias as such, with *Rhynchonella salteriana*, Stol., and *Ptychites gerardi*, Blfd. He certainly came across the lower group, but in the absence of known Trias fossils he represented it as upper carboniferous, containing numerous *Productus semireticulatus*, Mart. (sp.), *Spirifer rajah*, Dav. I have compared some of his original specimens with my own collection, and have no doubt that the beds are quite identical both in lithological character and probably in their fossil contents.

It might be urged that the presence of the Productus speaks for a Permian age of these deposits; but taking into consideration the fact that stratigraphically the complex of Trias beds is a connected series of deposits without any interruption, with the greyish black shales invariably at their base, the whole resting on a rugged and denuded surface of the carboniferous quartzite, it must be admitted that on this account alone the shales (Kuling shales of Stoliczka) must be included amongst the Triassic group. These shales resemble the Werfen beds of the Alps, not only in lithological character, but also in the fact that here as there they contain a number of older forms of life side by side with new arrivals. Such is, it appears, the case with the Werfen beds of Armenia[1].

The following forms of the 1st and 2nd groups of the lower Trias are identical with such of the Werfen beds of the Alps :—

Monotis claræ, Emm.
„ *angusta*, Han.
Gervillia mytiloides, Schl.
Modiola triquetra, Seeb.
Myophoria ovata, Gdf.
Avicula venetiana, Hau.

Nearly identical with a Hallstadt form is *Ophiceras* (*Amm.*) *densitesta*, Waag.[2]
All the other species represent earlier stages of forms found also in the triassic beds of the Eastern Alps.

So for instance :—

Otoceras woodwardi allied to { *Hungarites* (?) *Strombecki*, Griep. / „ *scaphitiformis*, Hau. / „ *zalaensis*, Bökh. }

Ophiceras tibeticum, n.s., allied to *Lytoceras simonyi*, Hau., and other *Lytoceratites*, occurring in the Lower Trias.

DESCRIPTION OF NEW SPECIES.

Class: CEPHALOPODA.

Order: TETRABRANCHIATA.

Family: *NAUTILIDÆ*

Genus: NAUTILUS.

NAUTILUS QUADRANGULUS, Beyr., *var.* BRAHMANICUS, n. s. Plate I, figs. 1—3.

This species is most nearly allied to the Liassic forms, of which *N. aratus*, Schl., is the representative. The shell is considerably involute, the umbilicus deep. The ventral side flattened, the section of the shell sub-angular. The descent to the umbilicus is vertical and sharply defined. Five radial lines of growth are visible, and a few broad indentations at intervals of about ¾ inch along the last chamber indicate a faint kinship of this form to *Nautilus fugax*, Mojs.[3] Towards the mouth the shell opens out, trumpet-shaped. What remains of the last

[1] Abich: Geol. Forschungen in den Kaukas. Ländern, 1st. Theil, Wien, 1878. *See* also Mojsisovic's Verh. Geol. Reichsanst., 1879, p. 171.
[2] Benecke's Geog. Pal. Beiträge, I, p. 369.
[3] Jahrb. k. k. Geol. Reichsanst., 1869, Pl. XIX, fig. 3.

chamber amounts to exactly one-half of the entire evolution. Siphon situated at about $\frac{2}{3}$ of the height (fig. 3). The septa show nearly the same lines as *Nautilus subaratus*, Keys.;[1] the pointed antisiphonal lobe marks this species at once as belonging to the forms of which *N. aratus*, Schl., is the type. The number of septa are about thirty in a whorl.

The only character which distinguishes this species from Beyrich's species *N. quadrangulus*[2] is the fact, that the German Muschelkalk form seems more compressed than our species, so far as I can judge from the figure given. But there can be no doubt that the German Muschelkalk species is a descendant of this lowest Trias form.

Likewise *Nautilus spitiensis*, Stol., is probably also only a later stage of development of this species, which is common in the Werfen horizon of the Tibetan Himalayas.

With the exception of the angular shape of the section of the whorls which is so marked in the Indian species, it agrees very nearly with *Nautilus subaratus*, Keys., both in general shape and course of the lobe line. In fig. 2 I have shown another specimen, which I cannot separate at present from the larger form in spite of the indication of a hexagonal outline of the section of the mouth as shown in the figure. It is probably only a younger individual of the same species.

It is very numerous in Bed 2 (horizon of *Posidonomya angusta*, Hau.) of the lowest Trias.

Class: CEPHALOPODA.

Order: ?

Family: *AMMONITIDÆ.*

Tribe: PINACOCERATIDÆ.

Genus: OTOCERAS, n. g.[3]

Amongst the numerous forms found in Bed 2 (horizon of *Posidonomya angusta*, Hau.), one of the most remarkable groups is that for which I propose the above name. Occurring, as they do, in a bed belonging to the lowest Trias, they form the connecting link of a group of forms, the first of which appear in the palæozoic epoch.

The earliest species belonging to the tribe of *Pinacoceratidæ* appear in the Devonian, where we find the *Sageceras sagittarius*, Sandb.

In the Permian of Armenia we find again several species, and representatives of it are found in India (Salt-range) and pass on into Upper Trias, where many species belong to that genus.

The species described under the above generic name appear in the lowest Trias as companions of a number of early Triassic types, in the same bed with

[1] Middendorf's Reise in Sibirien, Pl. IV, fig. 3.
[2] Abh. Akademie, Berlin, Pl. III, fig. 5.
[3] Οὖς, ὠτος = ear.

Pos. angusta, Hau. Though it seems that there are several varieties, if not species, amongst the numerous specimens obtained, I prefer to include them for the present under one collective name.

OTOCERAS WOODWARDI, nov. spec. Plate I, figs. 4 & 5, and Plate II.

Shell involute, with very deep umbilicus, with rapidly increasing outer whorls. The part of the shell nearest the umbilicus bulged out into an ear-like shape, giving the section of the shell (Plate I, fig 4*a*,) a more or less rhomboidal aspect.

It is very probable that the last whorl in adult individuals covered and enclosed the entire shell. In all the specimens which I collected there is a tendency to enlarge the latter whorls at the expense of the umbilicus. The sides of the shell are only slightly curved and slope towards the sharp knife-like siphonal side enclosing an angle of about 67°. The compressed siphonal side is one of the most characteristic features of this species. In one of the adult specimens (Plate I, fig. 4), this part of the shell has quite the appearance of a sharp knife, and only a faint indication of a three-edged termination is visible, whereas in some of the younger specimens (Plate II, figs. 1 and 3) and even in the older form (Plate II, fig. 2*a*) the tripartite character of the siphonal side is strongly marked. This character alone would stamp this species as belonging to *Hungarites,* Mojs.,[1] of which *H. scaphitiformis,* Hau.,[2] and *H. zalaensis,* Böckh.,[3] are the types, but the shape of the ear-like prolongation of the sides of the shell near the region of the second side-lobes is a character entirely absent in the Austrian genus. A line connecting the ear-like prolongations of the sides, or, in other words, the second side-lobes, will intersect the median plane in a point, from which to the siphonal margin of the preceding whorl is about the third of the entire distance between the point of intersection and the siphonal margin of the outer shell. A vertical projection of the inner margin of the first lateral saddle to the median plane will intersect that plane in the siphon of the preceding whorl.

From Plate I, fig. 4*a*, it will be seen that the proportion in the increase of lateral expansion of the last whorl increases rapidly at the expense of the increase to the height of the shell, and it is not at all improbable that, as I said above, the final chamber inclosed nearly the whole of the shell in adult specimens, which character is indicated in fig. 3 of Plate II, which shows the almost vertical sides of the umbilicus, but since drawing the plates I have worked out of some blocks of stone the fragment of a larger specimen, showing part of the last chamber with the umbilicus. The latter is very narrow and closing in towards the outer side. The shell is extremely thick near the ear-like prolongation in the umbilical region and covered with wrinkles. The shell is covered with fine wavy lines of growth S-shaped, slightly bent forward near the siphonal margin.

The lobes show some variation, mainly in the auxiliary ones, but these increase in number with the successive whorls in the same specimen. As shown in

[1] Verh. Geol. Reichsanst., 1879, p. 140.
[2] Denksch. Akademie Wiss., Wien, 1855, Pl. III, fig. 4.
[3] A. M. K. Földtani intézet, Pest, 1872, Pl. VII, figs. 1 and 2.

the drawings of lobes in Plate II, this species possesses a broad siphonal lobe ending on both sides of the semicircular siphonal saddle in a sharp point. The external saddle (fig. 1*b*) is moderately high and a little narrower than the siphonal lobe. The first lateral lobe is the deepest of all, of the same width as the external saddle, and at the base shows plainly a tripartite arrangement of the serration.

I remarked also that the corresponding lobes vary on each side of the specimen (fig. 1). Whilst the first lateral lobe of the left side shows plainly this tripartite arrangement of serration, those on the right side have an additional sharp point added to the lower margin of the lobe as shown in fig. 1*b*. The larger specimen, fig. 4, shows a still more complicated serration of this lateral lobe, similar also in figs. 3 and 5. There follows in all specimens a very large first lateral saddle, slightly bent towards the inner side, with following rather narrow second lateral lobe, serrated at the base, this serration varying in the different specimens. The second lateral saddle is only half as high as the first and great lateral saddle, rather wider in proportion to its height, and followed by one or two auxiliary lobes of varying course. In some specimens the first auxiliary lobe reaches only half down the rounded and broad second lateral saddle and is not serrated at the base and might be described as a rudimentary lobe; in others, figs. 2*b*, 4 and 6, the auxiliary lobes and saddles are similar in shape to the last lateral lobe and saddle, decreasing in size as they near the ridge (r), noticed above. Beyond this the sutural line runs in a series of rudimentary lobes and saddles to the sutural margin (s), where it forms a flat serrated lobe; on the antisiphonal side I noticed on prepared specimens (fig. 6) a saddle, as broad as high, sloping towards the margin (s) followed by a narrower but deeper lobe, serrated at base, and a second higher and wider saddle, similarly sloping towards the marginal side. The antisiphonal lobe is bipartite.

Locality.—South of Rimkin Paiar and north of Kiunglung encamping ground, head-waters of the Ganges river.

OTOCERAS WOODWARDI, var. UNDATUM, n. s. Plate I, fig. 5.

With the first described specimens and only at one locality were found a few individuals agreeing in general shape and lobes with *Otoceras woodwardi*, but, unlike even the larger specimens of this species, showing very marked wavy ribs, only very slightly bent forward near the siphonal margin, but swelling out near the middle of the side of the shell. As none of the other specimens show this character, I have thought best to separate it for the present as a variety of the other form.

Locality.—South of Rimkin Paiar, east slope of the Kurgudthidhar mountain.

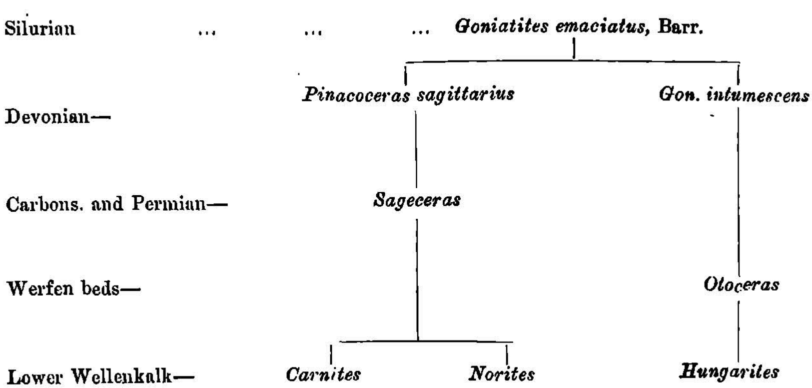
Allied forms.—The ancestors of the forms above described must be sought for in the family of the *Pinacoceratidæ*, Mojs., the oldest known ones of which occur in the Devonian of Oberscheld, *Pinacoceras sagittarius*, Sandb.[1] That *Sageceras*, known from the Permian and which like *Pinacoceras* lived up to the

[1] Sandberger: Schichtensystem in Nassau, p. 77.

Upper Triassic times, is a descendant from *Pinacoceras* is probable. There is another form which bears close resemblance to *Otoceras*, *Goniatites intumesens*, Bey. [1] var. *acutus*, which is a close relation of it and belongs to the Devonian system. In external shape, thickness of shell, fine lines of growth and the sharp-edged siphonal margin, they are all but identical, and from the figure (1*a*) it seems as if this species also, in a rudimentary stage, possessed the ear-like prolongations of the shell near the umbilical region. Turning to the lobes we find also the first lateral saddle largely developed and turned towards the umbilicus, and an indication of a second lateral saddle, but the lobes terminate in simple sharp points only, though corresponding in general proportion. The line of projection of the preceding siphonal margin (vertical to the median plane) cuts through the second lateral lobe near the inner margin of the great first saddle. We have here the true predecessor of *Otoceras* in Devonian beds.

The next younger form known is *Hungarites* (*Ceratites*) *strombecki*, Griep.[2] from the lowest Wellenkalk of Brunswick, which shows many characteristics of my genus, but most so in the form of the lobes (fig. 3) which are nearly identical with mine. Apparently also the projection of the siphonal margin of the preceding whorl passes through the second lateral lobe.

Whether the genus *Hungarites*[3] is a further development of *Otoceras* is not quite clear to me, but the description of the lobes given by J. Böckh[4] seems to point to a relation with the older form of *Otoceras*. Mojsisovic[5] hints at the possible derivation of *Pinacoceras* from *Goniatites emaciatus*, Barr.,[6] and indeed this species shows even greater likeness in general form and arrangement and position of the lobes to *Goniatites intumescens*, Bey., so that there is the indication of a pedigree, which would stand thus:



[1] Sandberger's Verst. Rhein. Schichtensyst., Taf. VII, fig. 1.
[2] Zeitsch. Deutsch. Geol. Gesellsch., Taf. VII.
[3] Verh. Geol. Reichsanst., 1879, p. 140.
[4] Földtani intézet, 1873, p. 156.
[5] Abh. Geol. Reichsanst., Bd. VI, p. 43.
[6] Syst. Sil., Vol. II, Pl. III.

PTYCHITES LAWRENCIANUS, DeKon.: Quart. Journ. Geol. Soc., Vol. XIX, Pl. VI, fig. 3.

As such I determine a few not well preserved specimens. They agree very well in general shape and in the formation of lobes with the Salt-range species, but with this exception, that my specimens exhibit traces of an ear-like ridge near the umbilical margin, thus showing some kinship to *Otoceras woodwardi*. Further researches in the Himalayas may reveal better specimens.

Of older forms the most nearly allied are *Goniatites hœninghausi*, Von Buch,[1] *G. intumescens*, Bey., var. *intermedius*, Sandb.,[2] and *G. buchii*, Vern.,[3] thus. showing in some degree a derivation from the early types of *Otoceras*, and itself representing a predecessor of the later *Ptychites* forms of the Muschelkalk.

Genus: NORITES.

NORITES PLANULATUS, DeKon., var.: Quart. Journ. Geol. Soc., Vol. XIX, Pl. V, fig. 1.

My species differs somewhat from DeKoninck's figure, in that the ribs on the sides of the shell are more strongly marked and seem indeed to form tuberculous masses; the siphonal part is perfectly flattened, and resembles in that *Norites gondola*, Mojs. This species is common in the higher beds (89) of the Campiler group of the lower trias.

There is an excellent predecessor to this species found in *Goniatites tenuistriatus*, Vern.[4]

Tribe: **LYTOCERATIDÆ.**

Genus: OPHICERAS.[5]

Under this generic name I propose to unite forms which possess the external characters of the *Lytoceratidæ*, but possess a much simpler lobe-line even than *Monophyllites*, and must be considered as an older stage of development of the *Lytoceratites*, which appear first in the Muschelkalk. For the description of the generic characters I refer to *Ophiceras tibeticum*, n. s., which may be looked upon as the type of my genus.

OPHICERAS TIBETICUM, n. sp. Plate III, figs. 1 to 7.

Shell compressed, section of whorls oval and widening near the umbilicus (see figs. 2 and 3); the latter large and shallow. The shell with seven to nine whorls, each covering a little more than a third of the preceding one. The shell is thick, especially so near the umbilicus, and covered with fine wrinkles or lines of growth S-shaped and bent forward near the siphonal side (figs. 4 and 5) In the body-chamber, they assume the character of fine S-shaped ribs (fig. 6), resembling in that stage the ribs of *Lytoceras simonyi*, Hau., with which species my form corresponds in many characters. At irregular intervals the shell swells into rounded bumps, largest near the umbilical margin. The siphonal side is rounded,

[1] Trans. Geol. Soc., Vol. VI, 2nd Ser., Pl. XXV, fig. 7.
[2] Rhein. Schicht. Syst., Pl. VII, fig. 2.
[3] Trans. Geol. Soc., Vol. VI, 2nd Ser., Pl. XXVI, fig. 1.
[4] Trans. Geol. Soc., Vol. VI, 2nd Ser., Pl. XXVI, fig. 7.
[5] Οφις = serpent.

and the wrinkles or folds run across it and join with those of the other side. In a larger fragment of a body-chamber, which I refer to this species (fig. 1), the back is smooth, and the wrinkles or folds show only near the umbilical side.

The lobes are simple; the projection of the preceding whorl intersects the second lateral lobe near the outer wall of the second lateral saddle; the siphonal lobe is much wider than high, with a moderately high siphonal saddle, separated by the siphon. The external saddle is about as high as wide. The first lateral lobe is very deep and narrow, followed by a high first lateral saddle, bent inwards. The second lateral lobe is narrow and reaches only half as low as the first one. The second lateral saddle resembles in shape and height the first one, followed by a lobe of about the same depth as the last one, situated at the umbilical margin. The internal sutures are very simple. A deep bipartite antisiphonal lobe is accompanied by a rounded low saddle on each side. The margins of all the saddles are entire and the arches of the lobes very finely serrated, and in younger specimens and the inner whorls of others, often entire. Some fragments of young individuals resemble in general shape this species, but show slight deviations in the lobe-line (fig. 7).

Both in general shape and number, and arrangement (though not shape) of the lobe-lines, this species closely resembles the Lytoceratite genera (*Monophyllites* and *Phylloceras*) of the Muschelkalk and Hallstadt respectively, and may be said to be an earlier stage of these forms.

The earliest appearance of a form belonging to the chain of which the above species is only a link may be said to be *Goniatites bohemicus*, Barr., from the Silurian, and can be traced through a variety of allied species to the Devonian of Nassau, where we find in *Goniatites æquabilis*, Beyr., an exact likeness of our Himalayan species. Both section of shell[1], general characters and striation, agree perfectly, and there is a strong resemblance even in the lobe-line. The external saddle is rudimentary, as is also the second lateral saddle, which is moved nearer the umbilical margin. But there, as in our species, we find a strongly developed and large first lateral lobe, with a bend towards the inner side, closely resembling the later Himalayan species. We have here connecting links of a long chain of forms beginning already in Silurian times and reaching probably high up in the cretaceous series, thus:

Silurian: *Goniatites bohemicus*, Barr., etc. etc.
|
Devonian: *Goniatites æquabilis*, Beyr.
|
Lower Trias: *Ophiceras*, etc. etc.
|
Muschelkalk: *Monophyllites*.
|
Hallstadt: *Phylloceras*.

etc. etc.

[1] Sandberger's Rhein. Verst., Taf. VII, fig. 10.

OPHICERAS HIMALAYANUM, nov. sp. Plate III, fig. 8.

Shell rather less evolute than in the last described species, the last whorls rapidly increasing in height, and in that resembling more the *Lytoceras simonyi*, Mojs., even than the last species. But both the sculpture of the shell and the lobes differ considerably from *Ophiceras tibeticum*. There are a number of nearly straight, only sightly S-shaped, ribs running across the sides of the shell, which near the commencement of the body-chamber (indicated by a small arrow in fig. 8) almost disappear and change into irregular fine wrinkles and bumps near the umbilical side. What remains of the body-chamber is about one-half of the entire whorl. The siphonal side is rounded, the umbilical margin sharply defined, descending straight down towards the shallow and wide umbilicus. The lobes are identical with those of the following species (figured in fig. 9*b*).

OPHICERAS MEDIUM, nov. sp. Plate III, fig. 9.

General proportions of the shell the same as those of the last described species, but the shell is nearly smooth and only shows slight radiating wrinkles, which disappear entirely towards the siphonal side and are only slightly bent forward in that region. The lobe-line, fig. 9*b*, resembles more that (fig. 7) which I considered as a younger individual of *tibeticum*, n. s. The siphonal lobe ends in two sharp points on each side of the divided siphonal saddle; the external saddle is a simple arch, rather wider than high, followed by a narrower, very finely serrated (at the base) first lateral lobe. The first lateral saddle is wider than high and bent towards the umbilical side. The second lateral lobe does not reach so far down as the first, is narrower, but also very finely serrated at the base. The second lateral saddle is low and broad, and reaches over the umbilical margin; on the antisiphonal side I noticed a deep and bipartite antisiphonal lobe with a rounded saddle on each side connected with the second lateral saddle by a finely serrated lobe-line, representing one or more auxiliary lobes.

MONOPHYLLITES WETSONI, Opp., Pal. Mitth. Plate LXXXVI, fig. 2.

Agrees well with Oppel's figure, both in outward appearance and course of lobe-line. It was found only in fragments, but is very common in the upper beds of the lowest Trias group—the Campiler beds of the Alps.

TRACHYCERAS (?) GIBBOSUM, nov. sp. Plate III, fig. 10.

With the above forms occurs an Ammonite, which in outline resembles somewhat *Trachyceras (Amm.) semipartitum*, Von Buch[1], but the latter is involute in a higher degree than my species, and consequently developes several auxiliary lobes which are wanting in our species. I have at present referred this form to *Trachyceras*, but it is very probable that it represents a connecting link between *Ophiceras*, n. g., and *Xenodiscus*, Waag., as exemplified in *X. gangeticus*, DeKon., and *Buchianus*, DeKon., which I venture to include in Waagen's new genus.

[1] Über Ceratites Akad. Wiss., Berlin, 1849, Pl. III.

T. gibbosum is moderately involute, leaving a wide and shallow umbilicus; the shell is thickest, near the middle of the sides, in the region of the "bumps," which occupy exactly the centre-line of the sides, and are about six in number in the last whorl. The inner whorls are quite smooth, and on the surface of the shell itself neither ribs nor striæ are visible. The section of the mouth is oval, widest about halfway up the sides. The siphonal side is perfectly rounded. The body-chamber, as far as it is preserved, amounts to about half a whorl (the arrow indicates the commencement of it, fig. 10).

The lobes are very simple and resemble those of *Ophiceras medium*, n. sp., and partly also those of *Trach. semipartitum*, v. Buch. Besides the low siphonal lobe there are one external and two lateral lobes with one auxiliary lobe, which is situated near the umbilical margin. The antisiphonal lobe is deep and ends in two minute points (fig. 10*b*).

Tribe: **AEGOCERATIDÆ**, Waag.

Genus: XENODISCUS, Waag.

XENODISCUS DEMISSUS, Opp.

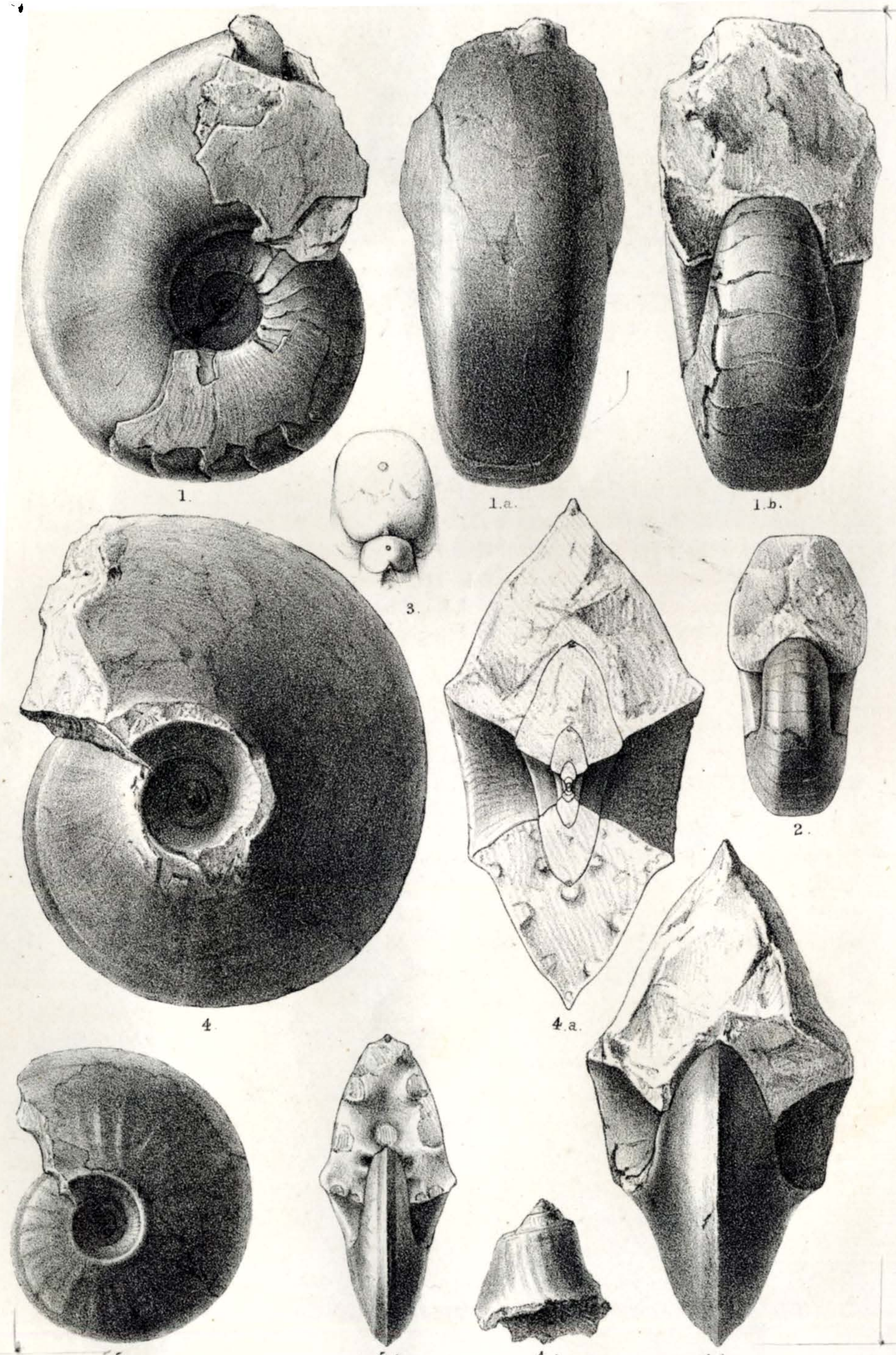
1862. *Ammonites demissus*, Opp.: Pal. Mitlh., Taf. 86, fig. 1.
1872. *Ceratites carbonarius*, Waag.: Mem. Geol. Surv., India, Vol. IX, Pl. I, figs. 2 & 3.
1879. *Xenodiscus carbonarius*, Waag.: Palæont. Ind., Ser. XIII, Pl. II, figs. 2 to 5.

With the species above described and in the same bed (2) with *Posidonomya angusta*, Hau., and other Werfen bed fossils, occur numerous specimens belonging to a chain of forms which might be roughly described as beginning with the flat and characteristic *Xenodiscus demissus*, Opp., and ending with *Xenodiscus (?) buchianus*, DeKon.

I have nothing to add to the description of the above-named species after the excellent exposition given by Waagen in the Palæontologia Indica, but may add, that there can be no doubt that Oppel's figure agrees with Waagen's species, as it does with my specimens. The species is so common in bed 2, that necessarily there is a great variety of forms, all, however, agreeing in the principal characters. They show greatest variation in the ribs or wrinkles of the shell, to which I may add that the shell itself is rather thick, especially so half-way up the flattened sides, and is covered by wrinkly lines of growth, which at intervals develope into ribs.

It is possible to arrange from amongst them a complete chain, passing from the evolute specimens (representing Oppel and Waagen's species) up to considerably involute varieties, and in that stage closely resembling the two species of DeKoninck's *Goniatites gangeticus* and *Cer. buchianus*.

Though Dr. Waagen does not say so in his description of the new genus, I presume that *Xenodiscus* is really the early stage of development of *Aegoceras*, Waag., and stands in the same relation to the latter genus as does *Otoceras* and *Ophiceras*, respectively, to *Pinacoceras* and *Lytoceras*.



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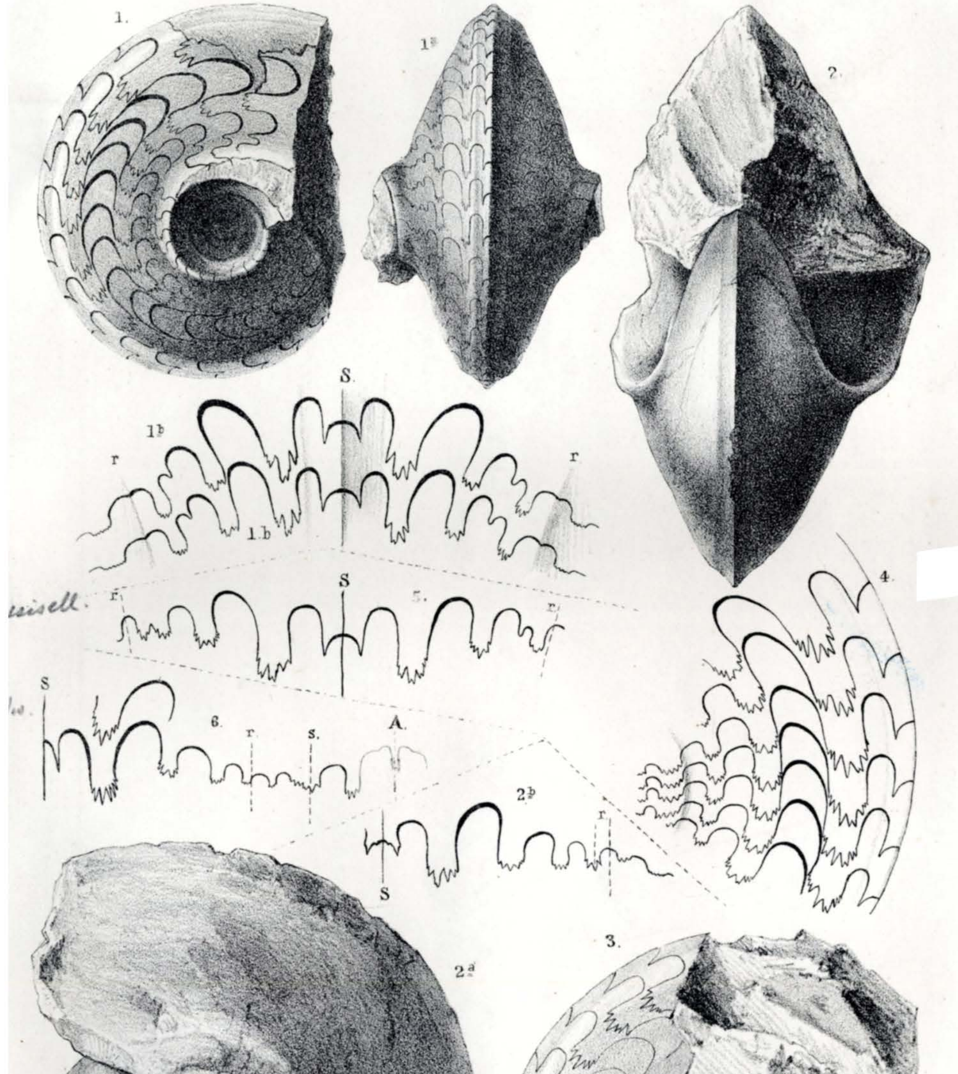
Griesbach, Lower Trias Cephalopoda.

Records Vol: XIII. Pl: II.



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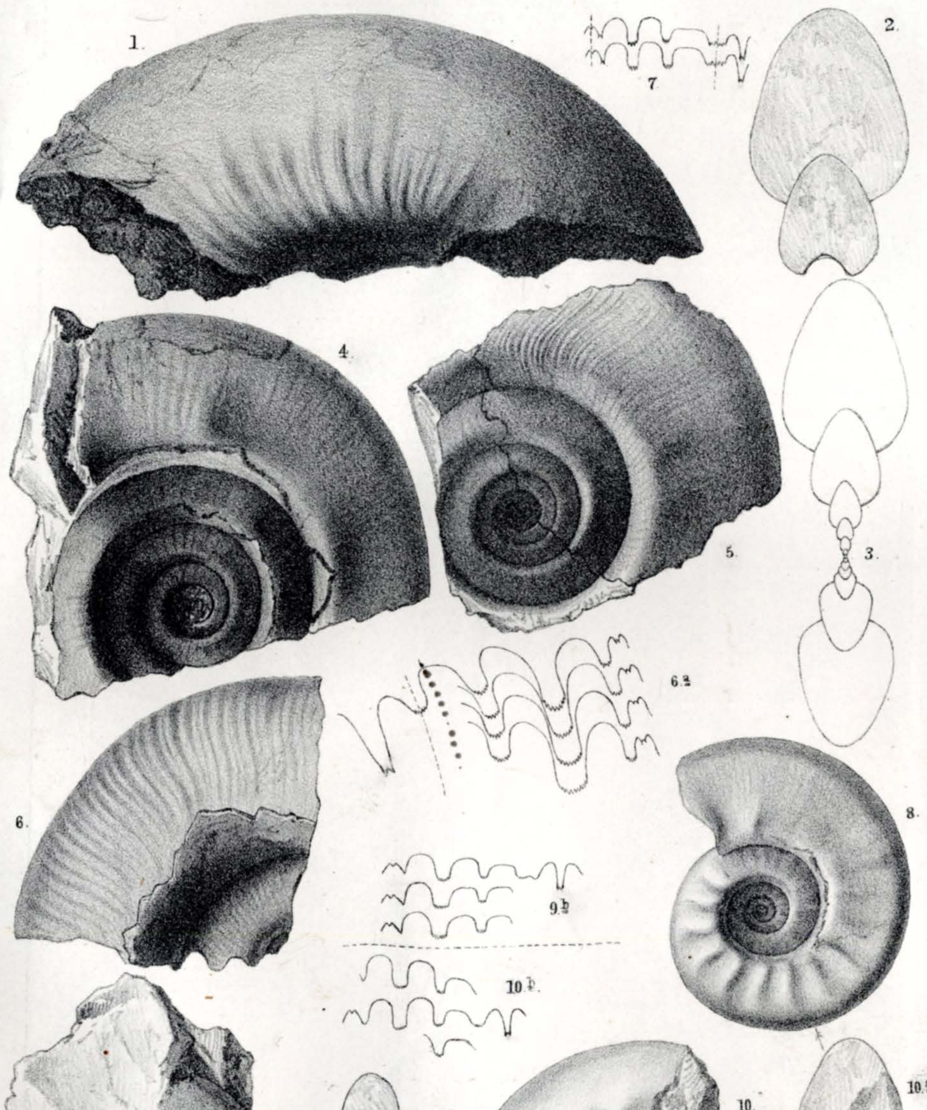
Griesbach, Lower Trias Cephalopoda.

Records Vol: XIII. Pl. III.



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Griesbach, „Lower Trias Cephalopoda" GEOLOGICAL SURVEY OF INDIA. Records Vol. XIII Pl. IV.

Drawn from nature with the Camera by the author.

PROFILE OF TRIASSIC AND RHAETIC CLIFF OF SHAL-SHAL.

Printed at the Geol. Survey Office.

EXPLANATION OF PLATES.

PLATE I.

Figs. 1 to 3. NAUTILUS BRAHMANICUS, n. s.
Fig. 4. OTOCERAS WOODWARDI, n. s.
Fig. 5. „ var. UNDATUM, n. s.

PLATE II.

Figs. 1 to 6. OTOCERAS WOODWARDI, n. s.

PLATE III.

Figs. 1 to 7. OPHICERAS TIBETICUM, n. s.
Fig. 8. „ HIMALAYANUM, n. s.
Fig. 9. „ MEDIUM, n. s.
Fig. 10. TRACHYCERAS GIBBOSUM, n. s.

PLATE IV.

Profile of Trias and Rhætic beds of Shal-Shal in the Tibetan Himalayas. The elevation of the base of the cliff (carboniferous quartzite) is about 14,000 feet above the sea.

ON THE ARTESIAN WELLS AT PONDICHERRY, AND THE POSSIBILITY OF FINDING SUCH SOURCES OF WATER-SUPPLY AT MADRAS, by WILLIAM KING, B.A., *Deputy Superintendent, Geological Survey of India.*

History and progress.

Some three years ago it was announced that operations had been commenced at Pondicherry with a view to the discovery of artesian wells,—a doubtful enough experiment when the position of that city on a wide alluvial flat bordering the sea is taken into account, and that few of the ordinary physical or stratigraphical features, usually considered as giving promise of such outflows of water, are apparent at first sight. Such features do, however, occur partially; and their possible existence became gradually so impressed on the mind of Mr. Ch. Poulain, the manager of the Savana and Oopallem cotton mills, that he urged on the proprietors the advisability of making experiments, and ultimately carried out a boring with such success that water is now issuing from the tube with a hydrostatic level of nearly three feet over the surface soil and a discharge of 44 imperial gallons in the minute.

Mr. Poulain, from time to time, during the progress of this first well, read a series of papers before the Government Commission on artesian wells, in which he gave his reasons on geological and physico-geographical grounds for expecting that water-bearing strata, or sheets of water with a head, might be tapped under the Pondicherry plain, at the same time giving short notes of the progress of his work.[1] The data so recorded and other information obtained personally from this gentleman have been largely included in the present paper.

[1] See Appendix 2.