MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. V. PT. I.

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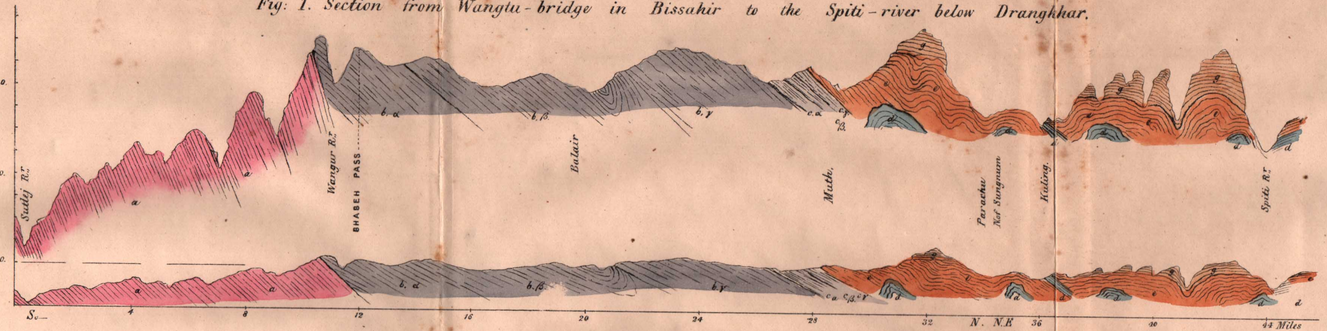

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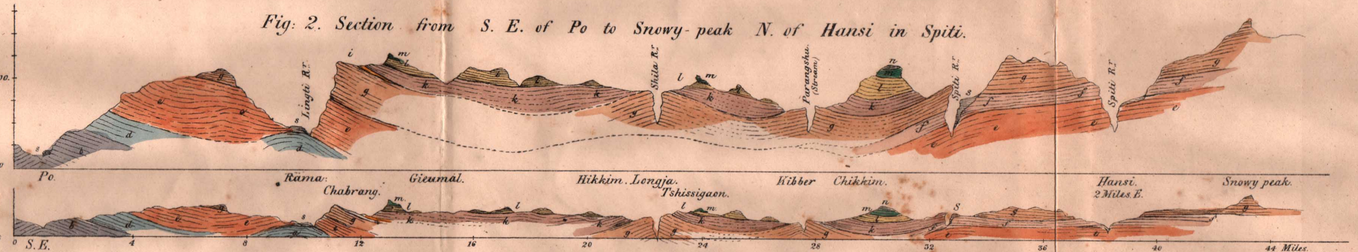

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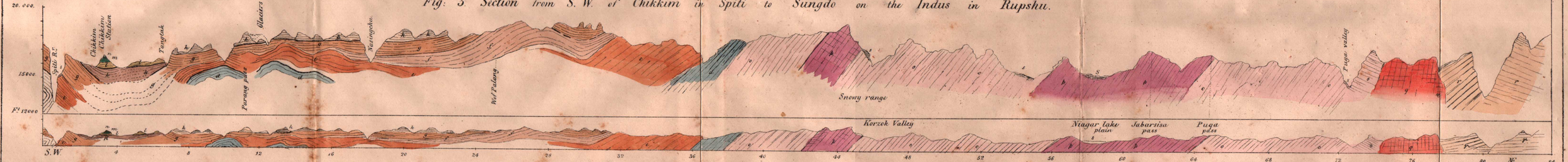

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On Tracing Paper by Shaik Munnooruddeen.

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MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Geological Sections across the HIMALAYAN MOUNTAINS, *from* WANG-TU-BRIDGE *on the River* SUTLEJ *to* SUNGDO *on the* INDUS: *with an account of the formations in* SPITI, *accompanied by a revision of all known fossils from that district, by* FERDINAND STOLICZKA, PH.D., *Geological Survey of India.*

CONTENTS.

INTRODUCTION.

THERE are few parts of India, which offer so many difficulties to the scientific traveller, as that elevated tract of mountains which borders the North-west of British India,—the North-western Himalaya. Several portions of this country, being partly independent or protected states, have rarely, if ever, been visited by any European traveller. And such visits as have been made have usually been in great haste, for the resources of the country do not generally admit of any long stay in one place. As a result of these great difficulties, we do not as yet know much of the natural wealth of this portion of the Himalayan ranges, although probably more of this, than of the more Eastern parts of this great system of mountains.

Difficulties of country.

It was not until 1851, that the first Geological section across the Himalaya, based on actual observation and research by the able Captain (now Colonel) R. Strachey, was published.* This was a vast step, and every one inter-

Strachey's observations, 1851.

* Quar. Jour. Geol. Soc. Lond. vol. VII. p. 292.

ested in Himalayan Geology must greatly regret, that the author has not since found time to make fully known to the public his investigations, which, no doubt, have been since 1851-54 considerably extended and corrected.

Other travellers.

The Geology of the Himalaya had not, however, been altogether neglected by previous travellers. The works of Moorcroft and Trebeck, of Herbert, Gerard, Jacquemont, Thomson, Cunningham and others, contain several notes of much Geological interest. Such notes, however brief they may be, will always be of high value, while they are based on unaffected and natural observations. Besides these cursory notes, I may also mention other papers treating more particularly on that portion of the North-western Himalaya, which we are about to describe more fully in the following pages,—we mean, the Spiti valley.

Gerard, 1832.

Dr. Gerard's "Observations on the Spiti valley" were published in the Asiatic Researches (Vol. XVIII pt. 2. p. 238). This paper contains only a few notes, on the last pages, regarding the occurrence of Ammonites in the Spiti valley. The author was apparently not much acquainted with Geology, and does not go much into Geological questions.

Hutton, 1841.

Captain Thomas Hutton's "Geological report on the valley of Spiti," &c., appeared in the Journal of the Asiatic Society of Bengal, 1841. p. 198. This report, so far as it is based on Capt. Hutton's own observations, and not on the authority of others, will, I think, always be found useful by any subsequent traveller along the same route. With regard, however, to his ideas or theories, we would simply quote the words of the editors of the Journal "for the views contained in this paper, the author alone is answerable." Indeed, no one who himself feels bound to progress in natural science, could be made answerable for theories such as are laid down in this paper, with an assumption of infallibility.

Wm. Hay, 1850.

The Report on the valley of Spiti by Captain W. C. Hay (Journal Asiatic Society, Bengal, 1850, p. 429) contains a chapter on Geological formations (loc. cit. p. 434,) the observations in which would have been of much greater value had the author not been so positive in his identifications of the Spiti strata with known European formations. Such statements, if not at least approximately correct, are very delusive, and prevent the reader from drawing his own conclusions, which otherwise he might do from any well-observed facts if correctly stated.

Theobald, 1862.

Mr. Wm. Theobald, Junr., published in 1862, "Notes on a trip from Simla to the Spiti valley," (Jour. Asiat. Soc., Bengal, 1862. p. 480). This paper does not contain any Geological notes. The author, however, mentions that they will appear with the examination of the fossils collected, at some future period, and I must state here, that I have had the valuable collections brought down in 1861, by Messrs. Theobald and Mallet, at my disposal, (with their notes on the district), and this collection added greatly to the number of fossils observed during our visit to the Spiti valley. I will have occasion several times to refer to this collection.

Medlicott, 1864.

The most recently published paper on Himalayan Geology is that by Mr. H. B. Medlicott.—"On the structure and relations of the Southern portions of the Himalayan ranges between the rivers Ganges and Ravee."* This paper will, we hope, be still fresh in the memory of the readers of our memoirs; its object was to elucidate the Geological structure of the Southern portion of the North-western Himalaya, between the rivers mentioned. That which has a special interest in connection with our present purpose is the part between the plains and the Sutlej; the Geological structure of this portion of the hills is represented on the sections given by Mr. Medlicott, pp. 18, 24, and 32. These three sections give an insight into

* Mem. Geol. Surv. of India Vol, III. Pt. 2.

the relations of the rocks between the plains on the South, and the Hatu Mountain near Narkanda to the North-east, of Simla. When Mr. Medlicott's report was published, the contrast between the Geological structure of the Southern portion of the Himalaya, and that of the Northern portion, so far as then known, must have been noticed by every reader. It was, therefore, of the highest interest to ascertain, if possible, the connection between these, chiefly metamorphic, rocks of the more Southern slopes, and the fossiliferous rocks of Spiti; which, since the time of Gerard's first discoveries, have been several times examined. The stratigraphical relations of these fossiliferous rocks in Spiti had not, however, been successfully traced out; and even Mr. Theobald's and Mr. Mallet's collections of 1861, gave no sufficient explanation, showing clearly a mixture of fossils from different formations. Such being the case, it was almost unavoidable to repeat the attempt to trace out the stratigraphical positions of the Spiti rocks. It is the object of this paper to give the results of this attempt.

Stoliczka and Mallet, 1864.

Charged with the reconsideration of these questions, to which I have just alluded, I proceeded with my friend and colleague on the Geological Survey, Mr. F. R. Mallet, in the beginning of June 1864, from Simla to the North-east, through Bissahir to the Spiti valley, crossing the Bhabeh Pass. The rocks in Spiti were submitted to a general examination, so far as it was possible to accomplish this during the short time of our Survey. From Spiti we proceeded across the Parang Pass to Rupshu and so through the Para, Tsomoriri and the Puga valleys as far as the Indus. After two days march along the Indus, we turned near Ronggo, through the Hanle valley to Hanle, and returned from this by a different route to Spiti, crossing the Tagling Pass. The Western and North-western parts of Spiti were somewhat more carefully examined, and we took our way back through Lahoul and Kulu. This route

Route.

enables us to give a few sections across the country we have examined.

Map.

The small outline map (Plate I,) will be found very convenient by those who are not versed in Indian or Tibetan Geography. On this map we have not attempted to give any Geological detail, indicating nothing more than the limited extent of the Jurassic ellipse (see below). The localities of fossils have been especially marked. The position of the sections previously published by Mr. H. Medlicott is shewn by a dotted line in the South-west corner of the map: that of our own sections is also shewn, and our routes are indicated by a broken line. The sections are shown on Plate II. They begin at the Wangtu Bridge in Bissahir, and may be regarded as a continuation of the sections I have already mentioned from Mr. Medlicott's paper; and taking these together the reader will be able to obtain a general idea of the Geological structure of this portion of the North-western Himalaya.

Sections.

The rocks of the Spiti valley will be found treated with somewhat more detail, and to elucidate the stratigraphy and relations of the different formations, we would direct attention to the Section Plate II. Fig. 2, which is taken from South-east to North-west in a longitudinal direction through the valley, or in the direction of the longer diameter of the Jurassic ellipse. It would be, we think, premature to give a Geological map of the part of the North-west Himalaya, which has been examined, until the parts adjoining to the North-west and South-east have been visited. The Spiti valley is only a small portion of a large secondary basin, the extent of which to the North-west and south-east has not yet been traced out. And only when this has been done, can a correct idea be formed of the manner, in which the different formations have been deposited, and of the connection in which they stand to each other. This work is in

progress, and, we would hope, can be accomplished without any great delay.

Fossils.

Besides the stratigraphical and descriptive details of the Geology, we have not omitted to give those Palæontological data, which are necessary to determine the age of the different formations, a point which will be found more fully discussed at the end of this memoir. A few plates of the newly discovered fossils have been given. These fossils, however, form only a small addition to the large number already known through the researches of Messrs. H. F. Blanford,* Salter† and Oppel.‡ A general revision of all known fossils from Spiti has, therefore, been attempted, and will be found recorded at the end of the Geological notes regarding each formation separately.

Position of country visited.

Before entering on the Geological part of this memoir, we had better allude briefly to the Geographical position and extent of our sections. The little sketch map already alluded to will shew the general position of the district. The section given (Fig. 1 Plate II.) starts from Wangtu Bridge (across the Sutlej), about 30 miles East-north-east from Rampur, the capital of Bissahir, through the Wangur valley across the Bhabeh or Taree Pass to Sungnum at the confluence of the Para§ with the Pin river. This part of the section runs nearly due South to North. It turns at Sungnum a little to the North-east along the left bank of the Pin river, until this stream joins the Spiti river a few miles above Drangkhar.‖

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* Jour. Asiat. Soc. Bengal, 1863.

† "Palæontology of Niti in the North-West Himalaya," Col. R. Strachey, Calcutta, 1865. Printed for private distribution only.

‡ Palæontologische Mittheilungen, 1864. Stuttgart.

§ *Para Kio river* on the Atlas of India Maps. Para is the name of the river. *Chu.* means flowing water, the water of a lake stationary is called *tso*; the *river* is called Para *Chu.*

‖ *Drang* means straight or vertical, and *khar* a castle; the name *Danka* as quoted by Mr. Theobald (Jour. As. Soc. Beng. 1862, p. 508) is inadmissible, and is quite unknown

The second Section (Fig. 2 Plate II.) is intended to illustrate the extension of the Jurassic basin in Spiti itself. It extends from South of the village Po on the Spiti river, over the high plateau along its left bank, passing near to or over the villages of Drangkhar, Gieumal, Hikkim,* Longja,* Tshissigaong,* Kibber, Chikkim Station, and terminates a little further to the North-west beyond the Lagudarsi† river.

The section (Fig. 3 Plate II) is taken from the left bank of the Spiti river, a few miles South-west of Kibber, over the Station at Chikkim, the Parang Pass, and along the left bank of the Para river in Rupshu; thence through the Tsomoriri and Puga valleys as far as Sungdo on the Indus river, a few miles to the West of the Mouth of the Puga Stream.

I may here remark, that the sections have been purposely selected along the road which we took, or over such places as we visited more or less closely during our trip. In a country such as this, where it would be exceedingly difficult to visit the whole extent of the mountain ranges, and where the greatest care is still necessary in fixing Geological facts, it is of essential importance not to go far from the basis of actual observation. Besides this, such sections have the additional advantages, that they can be examined by any subsequent traveller with much greater ease, than if they had been taken right across the hills in one direction, in which case it would have been nearly impossible to avoid introducing a good deal more of conjectural

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to the Spiti people. They say Dangkhar, the*d* having a peculiar sound, which may be expressed in English by addition of an *r*.

* The topography of the map of the Indian Atlas here requires some correction. The village *Hikkim* is about 4 miles South of the position, it is marked at on the map on the left bank of the Shila river. The point where Hikkim is marked ought to be named *Longja*; while on the right bank of the Shila, where Longja is marked, there does not exist any village. About two miles West of this point is a little village consisting of only two houses, and called Tshissigaong.

† The inhabitants assured me, that they never heard this name for the river before, and that it is always called Tagling-chu, and the river North of the Tagling pass, Nashing-chu.

matter. The sections are all given on the scale of four miles equal to one inch, and have been taken from a compiled map, partly copied from the sheets of the Indian Atlas (No. 47), partly from a tracing copy of the unpublished field maps of the Southern districts of Rupshu, for the use of which we are indebted to the courtesy of Captain Montgomerie, R. E., who conducted the survey of that country. The remainder of the map was completed from Col. Cunningham's published map of Ladak, &c., enlarged for this purpose.

In order to shew the details of structure, the scale for height has been enlarged as compared with that for distance : the scale for elevations is 5,000 feet to the inch. But to avoid the erroneous idea which almost inevitably results from such distorted sections, true outlines are also given, the scales for heights and distances being the same.

Elevations.

The heights given on the Trigonometrical survey maps have been in all cases used, all intermediate heights have been calculated from observations with the boiling point Thermometer by Mr. F. R. Mallet.

PART 1. SPITI.

In describing the different formations, we shall first give a few remarks on that portion of Bissahir, which extends Northward from Mr. Medlicott's sections, namely, from Narkanda to the Wangtu Bridge. There is scarcely anything of novelty to be added here, which has not been already noticed in Mr. Medlicott's report. An account of the great mass of gneiss, which we consider as the main Geological axis of the North-Western Himalaya, will follow. And then the several formations in Spiti will be treated of in the order of their relative age, and lastly, brief notes will be given of the rocks of Rupshu. General discussions regarding the evidences for the different ages of these formations will conclude our remarks.

Description of Bisahir.

Leaving Mr. Medlicott's sections at the Hatu Mountain near Narkanda* we pass in an East-north-east direction along the left banks of the Sutlej, from the gneiss to a great variety of metamorphic rocks. These consist at first, (before reaching Kotgurh) of quartzose and somewhat chloritic mica schists. Beyond Kotgurh to the East, there are first reddish mica schists with garnets, to which succeed grey and chloritic schists (*graue* and *grüne Schiefer* of Alpine Geologists), and in the valley of the Sutlej porphyritic gneiss. At Kotgurh, the schists dip with a slight angle to the North-east, and immediately above the gneiss, for a very short distance to the South-west; the gneiss itself dipping equally on the left bank of the Sutlej to South-west, and on the right bank to North and North-east, although at only a very slight angle. The river Sutlej, therefore, here flows in a denuded anticlinal.

Porphyritic Gneiss.

The porphyritic gneiss extends along the Sutlej to near the village of Dathnagur, where it is overlaid by grey mica-schists without garnets, apparently quite identical with those East of Kotgurh. The dip, although

* Mem. Geol. Surv. of India. Vol. III, Pt. 2. p. 32.

immediately above the gneiss it is to the North-east, very soon changes to South-west, and this latter direction prevails as far as the Nagri Stream, which, at its junction with the Sutlej, flows also in an anticlinal. On this stream, the rocks are a pure white quartz-schist which, to the East, is overlaid by grey and greenish mica-schist. The white quartz-schists re-appear a short distance from Rampur, and are again followed by mica-schists. A few miles East of Rampur quartzose schists are prevalent, occasionally with some hornblendic strata.

Rampur.

These hornblendic schists pass gradually into micaceous and talcose schists, which latter are of considerable thickness, and extend round the village of Gaora. The rocks between Gaora and Sarahan are chloritic, micaceous, and talcose-schists, often with fine crystals of Garnet and of Staurotide. At the last mentioned village (Sarahan) a thin bedded gneiss appears, soon assuming a porphyritic structure. Gneiss, either thin bedded, schistose or porphyritic, a kind of tourmaline-rock, (small crystals of schorl with quartz) and thin bedded and usually much contorted micaceous strata are the rocks between Sarahan and Tranda. From Rampur up to near this village, the dip is principally to the North-east. Before reaching Tranda specular iron is often met with in the micaceous strata, and also large masses of Biotite.

Gaora and Sarahan.

Tranda.

This mica is of a deep brown color, made up of small laminæ, which are broken and contorted in all directions, and occasionally traversed by small flakes of white Muscovite. The Biotite is very brittle, and can be easily pulverized, the Muscovite remains in its little flakes, when it has been mixed with the former. Near Tranda, the rocks dip to the West-south-west.

CHAPTER 1.—*Central Gneiss.*

To the East of the village of Tranda the rocks assume a very constant and peculiar character, which,—of course within certain limits of variation,—they retain all the way up to the Bhabeh or Taree pass. As this rock is especially well exposed at the Wangtu bridge, I shall proceed at once to describe its character at this locality, so often mentioned previously by Capt. Herbert, Capt. Hutton and other travellers.

Wangtu bridge.

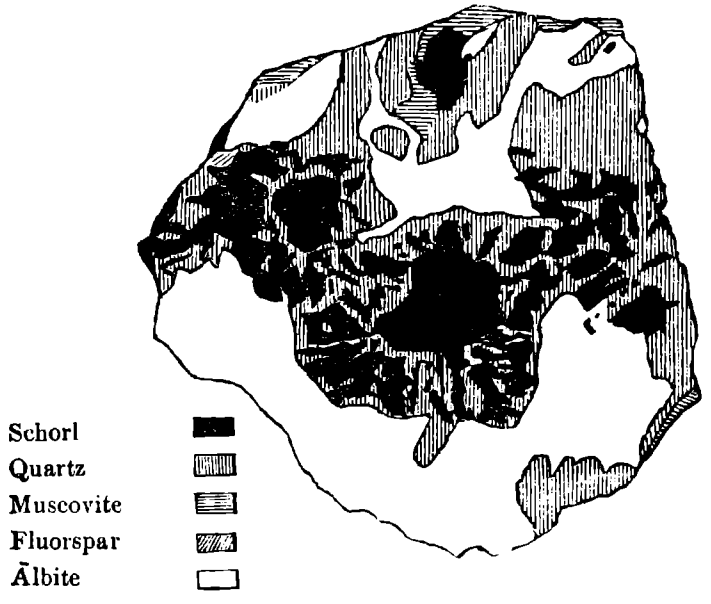
The gneiss at Wangtu has a porphyritic structure and can be generally described as granitoid gneiss. In fact as the stratification is usually in thick beds or is even obliterated, large pieces cannot be distinguished from granite. This gneiss consists of a mass of white Albite and white or greyish white Quartz in nearly equal proportions, large crystals of white Orthoclase and a considerable proportion of Biotite. This latter mineral occurs only in little laminæ, which are broken and contorted in every direction, and there is seldom a trace of Muscovite to be detected in the entire mass.* Pinkish Orthoclase is very rare here, and I noticed it only in one place near Paunda. This granitoid gneiss is traversed by a countless number of veins of Albite-granite, veins of unmeasured length, and from one to twenty feet in thickness. The principal mineral in these veins is a pure white Albite: next to it Quartz, Mica, black Tourmaline, and few other minerals. All these occur in large crystals, and the structure of the rocks is, therefore, eminently a porphyritic one. Col. R. Strachey tells me, that these veins of Albite-granite, in the neighbourhood of the Niti-pass, enter into the Silurian and even the secondary strata. There cannot be the slightest doubt as to their being of subsequent date to the gneiss, in which they are truly intrusive. This Albite-granite offers

Granitic gneiss.

* A similar structure was observed by Mr. Stur in the mica of the Central Gneiss of the Alps. Jahrb. d. K. K. Geol. Reichs-Anstalt. Vienna. 1856, vol. VII p. 407.

a rare opportunity for studying the genesis of the different minerals, and with this view I will make some observatons on an interesting specimen of which the subjoined figure is a representation reduced to half the measurements.

FIG. 1. SPECIMEN OF ALBITE-GRANITE, FROM WANGTU.



Successive formation of minerals.

Supposing the whole mass was fluid at a high temperature, the first mineral which crystallized was undoubtedly the Muscovite, which is the only Mica here as distinct from the common occurrence of Biotite in the gneiss itself. This Muscovite is often traversed and again recemented by all the following minerals and is therefore the oldest. Next to it the Tourmaline seems to have consolidated; this is always of the Schorl variety, and then the Beryl, Garnet and Fluorspar. All these minerals, although not of very common occurrence, have been found broken and cemented again by quartz, which surrounds every fragment of these minerals, so that there is no doubt as to their existence previously to the consolidation of the quartz. The Schorl is usually crystallized in six-sided prisms,* of which the shape can be easily recognized

* Three sided prisms, sometimes of a foot in length, are also not rare, especially in the Chandra valley.

in Fig. 1. These large crystals seem to have been cracked by the quartz mass to a limited depth, to which the quartz penetrated and cemented the fragments. This must, however, have been accomplished without much disturbance, and not in a very fluid mass, so that the original form of the Tourmaline crystal was retained. After the quartz consolidated and had surrounded the already formed minerals, the whole mass seems to have been cemented and filled up by the Albite, which itself comes very rarely into contact with the Tourmaline or any of the other minerals, except Quartz.

The successive ages of the different minerals can therefore be represented thus:—

1	2	3	4
MUSCOVITE.	TOURMALINE. Beryl, Fluorspar, Garnet.	QUARTZ.	ALBITE.

The Schorl is the most prevalent of the accessory minerals. The Fluorspar is comparatively rare and generally of a light green colour; the Beryls often attain a large size up to several inches, they are white or of a light-blue colour, and very brittle. This seriously interferes with their value for ornamental purposes. The Muscovite is found in large flakes, white, grey, or oftener brown, and not uncommonly in prisms. The Albite forms sometimes nearly one-half of the whole mass, and pieces of several maunds in weight are often met with, which consist solely of this mineral.

Wangur valley.

Proceeding Northward from Wangtu, in the Wangur valley, the gneiss is found to change in character considerably in some places, and to become even schistose from the large quantity of Biotite. The dip remains constant throughout from Wangtu up to the Bhabeh pass, to North and North-east, and usually at a high angle, varying from 30° to 80°. Beyond and near Yungpa, blue Kyanite is very common in the gneiss, occurring with Garnets. I have not observed the Kyanite in the veins of the Albite granite itself, but Col. Strachey states that, at Niti, it does

occur in the veins*. The gneiss extends to the North up to a few miles South of the Bhabeh pass. It was, however, impossible to see the exact junction, as the whole country was still sheeted in snow, when we were there (23rd June).

Kunzum-pass.

Further to the North-west, we traced the boundary of the gneiss and of the overlying Silurian rocks, about six miles in a straight line, South of the Kunzum pass, on a stream North of the Shigri glacier. From here the gneiss extends to the West as far as the Hamta pass, where it is overlaid by more schistose strata. The character of the rock in this section is exactly the same as described at Wangtu, only that the appearance of stratification is usually more obliterated. The characteristic veins of Albite granite occur here also: they are more frequent in the Southern portion of the gneiss, which is also the case in the Wangtu section.

Central Gneiss.

I have described this gneiss under the title of Central Gneiss, as I believe it to be the principal Geological axis of the North-western Himalaya. I cannot say anything about its eastern or western extension, but the description seems to apply as well to those parts of Kumaon and Gurhwal, which have been examined by Col. Strachey.

Metamorphic rocks, &c.

This Central gneiss is overlaid to the North by a tolerably regular series of palæozoic and of secondary deposits. To the South follows another great series of metamorphic rocks, gneiss, mica and chloritic schists, and slates of all descriptions. The southern gneiss is often found interstratified with mica-schists, and still more frequently occupying the tops of hills or ranges of hills, being regularly underlaid by metamorphic schists or slates. This latter gneiss has, geologically speaking, nothing to do with that called above Central gneiss, although it is often very similar in structure. My experience, as to the southern flanks of the Himalaya is

* Quar. Jour. Geol. Soc. Lond. 1851, vol. VII, p. 302.

very limited, and I therefore leave this point now, hoping that a closer examination may soon enable me to discuss it more fully. The occurrence of Central gneiss in isolated places South and North of the central ranges, which I have partly indicated, is of very high interest. I would point to the Chor Mountain, East of Simla, as an example of its occurrence to the South. And to the North of the central chain I have to mention the gneiss on the left bank of the Para river near Changrizing and West of Chango. This is a great mass of gneiss, with all the characters of the Central gneiss. Occasional layers of a hornblendic or chloritic and quartzose schist give the rock locally a slightly different appearance. I am, however, unable at present to say, in what way these outlying or sporadic masses are connected with the main axis.

Isolated points of Central Gneiss

at the Chor,

and Changrizing.

CHAPTER II.—*Palæozoic formations in Spiti.*

The Palæozoic rocks form the Southern and Western boundary of Spiti, and are the principal rocks in the South-eastern part of the valley. Silurian and carboniferous rocks are represented.

Before entering into a general description of the palæozoic rocks, I must remark, that we have to distinguish in each of the formations two local series, a Southern and an Eastern one. The first contains the deposits along the main axis of the Central gneiss; and the other, in the South-eastern portion of the Spiti valley, resting against a lateral extension of the Central gneiss extending to the North-east. The rocks in this second series are only little different, but always more highly altered than the others. There is no doubt that the two series are connected with each other a little to South-east of the Spiti valley, which part has not been surveyed yet; however, as it is unknown in

Two local series in each group.

what way they are connected, I prefer to treat each separately, specially with a view to the convenience of any future examination.

§ 1.—*Silurian—Bhabeh Series.*

1. *Section South of Muth.*—In the Section (Fig. I. Pl. II.) we see the Silurian rocks overlying the gneiss at an angle of between 30° and 50°, and dipping to the North-east by north, while the strata of the gneiss dip at a much higher angle. I have already remarked, that to our great regret the climatal conditions did not allow of our seeing and examining the actual junction of the Silurian rocks with the gneiss, all being covered with snow; but the boundary, as indicated on the section, is certainly correct within the limits of half a mile.

(a). The lowest beds, which we have examined above the gneiss, were on the right bank of the Wangur river, about three miles South-east of the Bhabeh pass. They were blueish grey slates and similarly coloured sandstones. Some of the strata of the slates were silky and highly micaceous, the sandstones often greenish and more or less siliceous. All the rocks (so far as visible) on the way of the Bhabeh pass were quite the same, and they continued also for some distance on the northern side of the pass, being somewhat more than 3,000 feet thick. Not a trace of any fossil has been observed in these rocks, and in my field notes, I considered them as corresponding to those strata, which Col. Strachey mentions in Kumaon as azoic.* Although we cannot insist much on the results of so cursory an examination as ours, still the occurrence of small particles of a blueish and reddish† slate in the next beds higher in the series is certainly

Lowest beds.

Bhabeh pass.

* Quar. Jour. Geol. Soc. Lond. 1851. Vol. VII, Pl. XVII.

† We have not seen any slates of this colour *in situ*.

not opposed to the idea, that this lower series may, on future examination, be conveniently separated as distinct from the other beds.

(b). A few miles North of the pass, the colour of the rocks changes gradually to whitish or pinkish. The strata are partly a grey strongly siliceous sandstone, with occasional calcareous beds, and partly a white or pinkish dotted quartz rock. Blocks of the calcareous beds are often met with of a cavernous structure, the limestone having been at first changed to magnesian limestone—dolomitic limestone or dolomite—and afterwards again decomposed in part. The name 'Rauchwake' is often used for this kind of decomposed limestone. These rocks, chiefly siliceous, extend to about two miles North of the camp Balair; at this place, although generally regularly and conformably bedded, they are greatly contorted. Fossils were first noticed about five miles North of the Bhabeh pass in the siliceous and carbonaceous sandstone. They consisted of some very poor impressions of Brachiopoda, apparently an *Orthis*, but not sufficient to determine even the genus confidently.

North of Bhabeh.

(*c*). Leaving Balair we come soon again upon greenish and blueish sandstones, sometimes highly micaceous, often thinly laminated, or more coarsely bedded, and occasionally with some calcareous and slaty beds interstratified. In these latter beds some impressions of Brachiopoda have also been noticed, but not in a better state of preservation than those just mentioned. This third series of beds extend to within about three miles to the South of Muth, the first village on this road to Spiti.

North of Balair.

Next, South of Muth, the Silurian rocks are overlaid by a purple quartzite or quartzose conglomerate; both will be mentioned hereafter.

2. *Sections in East Spiti.*—I have already remarked (p. 16.) that a portion of Central gneiss appears in the most eastern part of the Spiti valley, on the left bank of the Para river. The gneiss is here overlaid by dark thin-bedded slates and sandstones. These slates dip to the North-east or nearly so towards the gneiss, although they are in some places on the banks of the Para river distinctly seen to overlie this rock. My opinion, formed on the spot, was that some denudation must have taken place further to North or North-East, and that in consequence of this all the rocks assumed a slight north-easterly dip. This is, of course, merely a supposition, requiring further investigation and proof.

East Spiti.

Near the village of Kuri I observed a great number of fossils (Brachiopoda) in the sandstone, but all these were only visible in sections on the weathered surfaces of the rock. Nothing distinct could possibly be made out; when a piece of the rock was broken off, no trace of the fossils could be noticed. Opposite Shalkhar, I often noticed in the slates Crinoid remains, which seem to belong to the rootlets of *Mariacrinus* or some allied genus. Above Shalkhar, the slates partly alternate with a greenish quartzose sandstone, and towards the top of the Kyagur pass there is a considerable thickness of blueish and whitish quartzites.

Near Kuri; Brachiopoda.

Shalkhar: Crinoids.

Following the section from the Para river to the West along the left bank of the Spiti, we see the slates, above the confluence of the two streams, overlaid by a kind of shales, which here rise up to the top of the hills, and which have a still greater thickness further on to the West. From the right bank of the Ghiu stream the road leads over quartzose schists, in part highly metamorphic. They are generally of a light grey or yellowish colour, either purely quartzose, or alternating with grey silky beds, which exhibit on the flakes a very fine parallel foliation; both are talcose and thinly bedded. The strata are

either horizontal or dip with a very slight angle to North 20° East. Further on towards the camping-ground at Hiuling the strata dip for a short distance to the West; and the whole series of these quartzose schists seems to have been therefore upheaved in the form of a dome.

Hiuling.

At Hiuling itself beds of impure yellowish limestone are not uncommon, and in proceeding to the West a darkish quartzose sandstone coarsely stratified is found to overlay them. A vast thickness of dark brown crumbling and splintery shales, alternating with greenish sandstones and light coloured quartzites succeeds, extending all the way from Hiuling up to beyond the village Po. They dip on this side of the river to North-by-east, and on the right bank chiefly to the West. We did not notice any fossils in these rocks, and as they very much resemble, in their mineralogical character, undoubted carboniferous strata, any separation from these is by no means certain. At Thabo large blocks of sandstone and shale are seen, full of a *Spirifer*, but they appear to have come from above, where there are true carboniferous rocks. Both these groups of beds, however, as already stated, resemble each other much.

Thabo.

One fact induced me not to separate the whole series of rocks from Changrizing up to Po, and that is, the occurrence of beds of greenstone all through the series. This rock is either highly crystalline or a good deal decomposed, and consists of diallage and a yellowish white felspar in small particles. It occurs not in veins, but in regular beds between the other rocks, usually of no considerable thickness, from 10 to 40 feet, and it partakes of the disturbances and contortions of the other rock, as may be distinctly seen in several places along the bare sides of the Spiti river. It must, therefore, be coeval. Iron pyrites is amply disseminated through the rocks, and, by its decomposition, gives rise to the formation of gypsum, arragonite, and of several efflorescences of alum, potash, soda, &c.

Beds of greenstone.

Difference in sections.

The difference between this section and that across the Bhabeh pass consists chiefly in this, that the lower strata here are more altered, in a few places truly metamorphic, and that the higher beds are chiefly slaty. To trace out the connection and relation of the two to the South-east will no doubt be a very interesting task. At present we only know from Capt. Hutton's report,* that he met the first slates above the gneiss to the South of the Hangrang pass, and Dr. Thomson equally mentions limestone (? Carboniferous or Triassic) for the first time in crossing the Hangrang pass.† Mr. Theobald, in company with Mr. Mallet, visited Spiti in 1861, and they brought, from the southern foot of the Manirang pass, some chloritic schists, and from higher up dark silky slates, in which *Chætetes Yak*,‡ Salter, is very common. With this occur some other impressions, which are no doubt of organic origin, but it is not possible to say whether they belong to some kind of fucoid or to Graptolites. The slates themselves are very like those which we met below (South of) the Bhabeh pass, and remind one much of Mr. Medlicott's Simla slates.

§ II.—*Silurian (?),—Muth Series.*

Three bands.

1.—Returning to the Bhabeh section (Fig. 1, Pl. II) there will be found above the true Silurian rocks a thickness of beds of about 1,000 feet, distinguished by a different shade of blueish colour, and consisting of three separate bands. These are the rocks which we are now about to describe, and the certain age of which is left undecided.

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* Jour. Asiat. Soc., Bengal. 1841, pp. 205, 206.

† Travels in the N. W. Himalaya, 1852, p. 99.

‡ Strachey's Palæontology of Niti, &c. Calcutta, 1865, p. 50.

(*a*). *Purple Rocks.* The lowest band of this series of rocks is very remarkable from its purple colour, which enables us to trace out the boundary between the lower and upper strata with much facility. At the bottom of this band is often seen a small thickness of a red quartz conglomerate in which the pieces of quartz remain white. The greater thickness moreover consists of a purple quartzitic sandstone, which sometimes alternates with thin layers of slates of the same colour. Both the conglomerate and the sandstone, near the junction with the previously described greenish sandstones, alternate with these in thin strata, although, on the large scale, the boundary is well defined. Such an alternation of a few layers cannot be regarded as of great importance at the junction of two successive series of rocks, although it is always deserving of careful notice. No trace of any kind of fossil has been noticed in these purple rocks, the total thickness of which is between 500 and 600 feet.

(*b.*) The next band is a light-coloured arenaceous limestone, in part largely siliceous. Some of the beds are purer limestone of dark colour. The total thickness ranges from 300 to 400 feet. The rock can always be easily recognized by its weathering brown on the surface, even in small fragments. Several fossils have been noticed here, but unfortunately in such a bad state of preservation, that it is impossible to come to any satisfactory conclusion as regards their age. They were—

Plants. 1.—Impressions not unlike some *Sphæro-coccites.*

Corals. 2.—*Syringopora* sp., a semi-globular large coral, composed of numerous, more or less parallel, chiefly pentagonal tubes, the width of which is usually 2 millimetres.

3.—*Cyathophyllum* sp., large species with elliptical section.

4.—*Cyathophyllum* sp., another species, resembling some younger *Placosmilia* with a much elongated, compressed section.

Echinoderms. 5.—Crinoid stems, belonging apparently to two different genera. I am not acquainted with anything like these.

Brachiopoda. 6.—*Orthis* sp., resembling *O. thakil,* var. *c. striatocostata,* Salter:* besides these there are other fragments which could be referred to the var. *a. convexa* of the same species.

7.—*Orthis,* sp., in form and ornamentation much like *O. compta,* Salter, (*ibid,* p. 43.)

8.—*Orthis* sp., another species resembling the little *O. tibetica,* Salter, (*ibid,* p. 42.)

9.—*Strophomena* sp., the single specimen found is not unlike the Carboniferous *S. analoga,* Phillips, although the rugose undulations around the beak are less regular and recall those of *S. halo,* Salter: which may possibly be a young shell of this.

10.—*Orthis* sp., conf. *O. resupinata,* Martin, from the carboniferous series.

Annelida. 11.—*Tentaculites* sp., apparently the same as mentioned by Mr. Salter from the Silurian rocks of North of Kumaon.

(*c.*) The third band, separated in the Bhabeh section, is a white quartzite, either purely white or oftener with small brown spots, disseminated throughout. The thickness is between 200 and 300 feet. No fossils have been observed.

In justification of the heading of this series of rocks, which I left doubtful as regards its age, I must refer the reader to my conclusions. I may only mention here, that all the rocks of the Muth series lie conformably on those of the Bhabeh series.

* Strachey's Palæontology of Niti. Calcutta 1865, p. 39.

2.—In the section following up the course of the Spiti river from the East there does not anywhere exist such a strong demarcation of the Muth series, but an indication of it seems to be present, as seen on the hills above Po and above Thabo. The dark shales and slates, described above as Silurian, are followed towards the tops of the hills by four bands of rocks, of which the lowest is pinkish, the following dark brown, the next white, and the top beds are concretionary limestone — apparently, and judging from pieces of it down below, true carboniferous. This, however, is only correct so far as it was seen from the bottom of the valley, and I cannot vouch for the accuracy of the statement, as it is hardly possible to climb up those precipices, and without fossils it must remain an undecided question.

Near Po and Thabo.

§ III.—*Carboniferous,—Kuling Series.*

The white quartzite of the Muth series is, to the South of the village, overlaid in one place by a small thickness of a carbonaceous, concretionary shale, and a little farther to North-east by undoubted triassic limestone. I regret not to have observed any fossils in the concretionary shale, which is followed a little higher up by triassic limestone also. In so far I am not certain whether the *true* carboniferous rocks rise here higher up and overlie the white quarzite. However, only a very short distance North of the village the carboniferous rocks appear under the trias, and here with very characteristic fossils.

The prevalent rocks of the Kuling series are a dark brown crumbling shale and a light coloured mostly whitish quartzite, generally speaking very difficult to distinguish from the top beds of the Muth series. The total thickness is from 100 to 400 feet, but is generally not considerable. The quartzites are

Thickness.

in some places the lower beds, and in other places, as below Drangkhar, they are interstratified with the splintery shales. These latter are sometimes very micaceous or carbonaceous, and even pass into a black limestone, with fossils, which is exposed about half way between Kuling and Drangkhar in the Pin valley. To the North-west of the village Po the carboniferous rock is partly a greenish sandstone, containing *Spirifer Keilhavii*, partly a blueish concretionary limestone with *Spirifer Moosakhailensis* and some Bivalves, partly it is the common brown and splintery shale. The rocks differ locally a good deal.

Drangkhar.

Po.

The first place, where we had a good opportunity of studying the carboniferous rocks was at the village Kuling in the Pin valley. Opposite, on the right bank of the Pin, at the village Khar, the carboniferous quartzites, which are here either pinkish or white, have a thickness of about 300 feet, and are upheaved in a dome-like form. They are overlaid by carbonaceous shale and higher up by triassic limestone. From this village only a portion of the rocks extends to the other or left bank of the river, and is seen here in a remarkable position, which would lead any one into an error, if he did not carefully take record of the fossils found in the different strata. Triassic limestone, quartzite, shales, and again triassic limestone are seen apparently quite conformably over each other! It is evident that the lower triassic beds which, farther to the west, lie nearly horizontal, must, at the small stream west of Kuling, have been first upheaved, and then, by some lateral force acting from the East, again depressed. (See section p. 34). The quartzites are here chiefly white and only about 100 feet thick; they contain impressions of *Spirifer Moosakhailensis* in great number. The shales above are about 150 feet thick, and full of *Spirifer Keilhavii* and *Productus semireticulatus*. It is, however, impossible among thousands of speci-

At Kuling.

Reversed strata.

mens to obtain one, which has not suffered from lateral pressure, the effect of which has acted on all the fossils in the same direction and pressed them often perfectly flat. *Spirifer Moosakhailensis* is in these shales comparatively rare, although it does occur as well, and has been brought also by Dr. Gerard and Mr. W. Theobald.

Compressed fossils.

Following down the Pin valley a few miles to East of this locality the carboniferous rocks appear, distinctly exposed, in great distortions, the great mass of the shales below and the quartzites above. Still farther on to East in the Spiti valley proper, at the mouth of the Lingti river, North of Drangkhar, the quartzites and shales are found alternating with each other in comparatively thin beds, and higher up along the Lingti river, towards and beyond Lilang, the same are met again, below the Trias, always with the characteristic Spirifers and Producti.

North of Drangkhar.

Carboniferous rocks of this character can be traced all along the Spiti and the lateral valleys, as far as Losar, and towards the Tagling-lá and the Parang-lá on both sides. It would be of little use to enumerate all the localities, and it is sufficient to say, that they appear under the Trias, usually in dome-shaped upheavements, which I believe are only the visible portions of repeated wave-like foldings of these and probably of all the lower strata. *Spirifer Keilhavii* and *Productus semireticulatus* are the commonest and often the only fossils, which are to be met in this district.

Losar, Tagling, &c.

Fossils of the Kuling series.

The following is a list of all the carboniferous fossils, which have been observed in Spiti;

1. SPIRIFER MOOSAKHAILENSIS, *Dav.* The Spiti specimens are generally much broader, having larger wings, than those from the Punjab, but they are otherwise undistinguishable. When the fine concentric laminæ become obliterated, and also the fasciculi of ribs less distinct, it becomes very difficult to separate such specimens from the *Spir. striatus,* Martin. In truth any real distinction between the two species appears to be by no means so certain, as it might appear to be. One character is well marked in all the Spiti and the Punjab specimens, that is, the strong and sharp fold on the dorsal valve, and a corresponding sinus on the ventral valve. Neither of these appear to have been noticed so strongly expressed in any figured specimens of *Spir. striatus.* Should this character not prove essential, I confess, I am at a loss how to distinguish between the Indian and European forms; especially those which Mr. Davidson figures and describes as *Spir. striata,* Martin, *var. attenuata,* Sow. (Palæont. Soc., Lond., Foss. Brachiopoda. 1857. Vol. II., Pt. 5., p. 20, pl. II., f. 12-14.) It is certain, and indeed very remarkable that, so far as the present materials allow a conclusion, both the species—if kept separated—are quite similar in all stages of growth and exhibit the same variations.

The species has been observed in Spiti at Muth, Kuling, Po, Losar and other localities, but always scarce. It occurs abundantly in the carboniferous rocks of the Punjab.

2. SPIRIFER KEILHAVII, *Buch.* (Abhandlungen der k. Akad. Berlin, 1846, p. 74, pl. 5, fig. 2. *Spirifer Rajah,* Salter, Strachey's Pal. of the N. W. Himalaya, 1865, p. 59.) This is a very common species in the carboniferous rocks of Spiti, wherever they are met with. It agrees in all its characters so well with the species figured and described by Leopold von Buch from the Bear Island, that a separation is impossible. I am happy to state this in justification of Mr. Salter, who proposed the new name only on account of his having been assured that it occurred in Triassic beds. He never lost sight of its being a true carboniferous form, and of its being so closely allied to *Sp. Keilhavii,* that he could hardly distinguish between them.*

* See Strachey's Palæontology of Niti, &c., pp. 54, 59, 73, and note by Mr. Oldham in the Appendix p. 110.

3. SPIRIFER TIBETICUS, *Stol.* Pl. III. Figs. 1-2.

Sp. testa rhomboidalis; valvis convexis atque crassatim costatis, jugo moderate elevato, bidiviso, sinu in medio uni-costato; rostro protracto et incurvo; area magna, triangulari, deltidio bipartito; superficie minutissime punctata.

The shell is rhomboidal and the hinge line only very little longer than the greatest width of the valves, which are more or less convex. If the shell is thicker (Fig. 1), the beak is usually not so much prolonged but more incurved: the contrary takes place in a shell which is more depressed (Fig. 2). Equally with these modifications varies the size of the triangular area, the fissure of which is partly covered by a pseudo-deltidium. The mesial fold is not much elevated, consisting of two thick costæ, on each of the sides of which there are 7 or 8 simple ribs. The sinus of the ventral valve is not very deep but broad, and has in the middle a slight rib.

The surface of the shell is all over finely punctated as is charàcteristic for *Spiriferina.*

This species has been brought by Dr. Gerard from Spiti and is probably the same, which Mr. Salter (Strachey's Palæontology, 1865, p. 54) mentions from the Oxford collection; "wide species, with two narrow folds in front." It is of the form of *Sp. octoplicatus* and, so far as I can judge from the adherent matrix, a carboniferous fossil. I have met with only one loose specimen, which I found near Kibber. The rock adherent to it is a slate, as I know it from the carboniferous rocks only, although I am unable to vouch for its sure position.

4. SPIRIFER ALTIVAGUS, *Stol.* Pl. III. Fig. 3.

Sp. testa sub-rhomboidalis, pinguis; rostro valde prolongato atque incurvo, area triangulari; deltidio bidiviso; fissura perlonga, angusta; jugo bipartito, sinu in medio unicostato; superficie granulosa.

Shell sub-rhomboidal, being nearly as high as broad; the hinge line is a little longer than the greatest width of the shell, but its extremities are not separately extended. The beak is very much prolonged and slightly incurved. The area is large, triangular, with fine horizontal lines, divided by a long but narrow fissure, which is partly covered by a pseudo-deltidium.

Both the valves are very convex, the mesial fold is bipartite, and the sinus has in the middle one rib. Besides there are on each side 8 to 10

thinner ribs, which, in proceeding towards the periphery, curve slightly outward. The ribbings on the fold and those bounding the sinus of the ventral valve are the strongest of all. This species has been found by Dr. Gerard with the former in Spiti. It is, by the greater convexity of the valves, of which the ventral one is very much extended, and by the finer and sharper ribbing, easily distinguished from *Sp. tibeticus*, n. sp.

5. PRODUCTUS PURDONI, *Davidson.* (Quar. Jour. Geol. Soc. Lond, 1862, Vol. XVIII., p. 31, Pl. 2, f. 5.) Only a single indistinct cast has been met with at Kuling. Col. Strachey found the species at the Chorhoti pass, and it does not seem to be rare in the Punjab.

6. PRODUCTUS SEMIRETICULATUS, *Martin*, (Davidson, British Foss. Brachiopoda, vol. II., p. 149, pl. 43, figs. 1—11, and pl. 44, figs. 1—4,) occurs throughout the carboniferous shales of Spiti and farther to North-west. The specimens never attain here such great size as in the English mountain limestone, or even further to westwards in Kashmir.

7. PRODUCTUS LONGISPINUS, *Sow*, (David. l. c. p. 59 pl. 35, Figs. 5—17) has been found in a few specimens in a black carboniferous limestone about 3 miles East of the village Kuling in the Pin valley.

8. AVICULA *sp.*, from near Muth; with distinct concentric striæ of growth only and a long wing; not sufficient for description.

9. CARDIOMORPHA *sp.*, from North-west of Po; a pretty large species with broad concentric folds.

10. AVICULOPECTEN *sp.* occurs very abundantly disseminated through the carboniferous limestone North-west of Po, with *Sp. Moosakhailensis.* It is a broad, sublævigate shell of considerable thickness, but we have not been able to procure even one perfect specimen, which would show sufficiently the characters necessary for the determination of the species.

11. ORTHOCERAS (?) *sp.* Only one part of a straight concamerate shell has been found in the carboniferous quartzites at the mouth of the Pin valley: it may belong to this genus.

CHAPTER III. SECONDARY FORMATIONS IN SPITI.

§ *I.*—*Trias.*—*Lilang series.*

Above the carboniferous rocks, or the Kuling series, we meet with a vast thickness of dark-coloured rocks, chiefly limestones, of very different description as to their mineralogical characters, and belonging to different formations. The first group of these limestones, which are of Triassic age, may be called the *Lilang series*, from the village Lilang on the Lingti river, a place where these rocks can be very well studied. I may just as well remark here, that there are, to the best of my knowledge, no other beds between the carboniferous and these triassic strata in Spiti; I mean, carboniferous beds with *Spirifer Keilhavii* and *Productus semireticulatus* are immediately overlaid by beds with *Halobia Lommeli* and *Ammonites floridus*.

Lilang.

No intermediate beds.

Returning to our section (Fig. 1) across the Bhabeh pass we find, above the highest beds of the Muth series, or in places above a small thickness of the supposed Kuling series, a dark grey or black limestone, which is either compact or finely oolitic. I am unable to come to any decisive conclusion about these limestones. There can be no doubt, that the greater part of these oolites is of inorganic nature, true oolitic grains, consisting of concentric layers. On the weathered surface of the rock, however, there are sometimes forms seen, which have quite the appearance of Quinqueloculinæ, and others of Globulinæ, &c. The first triassic beds South of the village of Muth consist of that oolitic limestone with a *Spirifer* allied to *Sp. fragilis*, *Rhynchonella Salteriana*,* *Halobia Lommeli*, and a great number of Crinoid stems, which probably belong to *Encrinus Cassianus*, Lbe. (usually called *E. liliiformis*.)

Origin of structure.

* With regard to the new species the reader is referred to the Palæontological notes farther on.

Fragments of Ammonites occur occasionally, but they are more common in the interstratified beds of compact black limestone. I collected here *Am. Jollyanus*, *Khanikofi* and *Thuillieri*.

Passing a little to the North of the village of Muth we find the triassic beds above the carboniferous sandstones and shales, principally composed of little bivalves, many of which have a striking resemblance to forms known from St. Cassian, and are probably identical as *Arca impressa*, *Monotis lineata*, and others.

Pin valley.

All through the upper portion of the Pin valley, from Muth to Sungnum, the triassic limestone is seen on both sides of the river in beds, from 1 to 2 feet, greatly disturbed and contorted. Some of the principal features of the dislocations are noticed in the section. Except *Halobia Lommeli* and traces of *Brachiopoda* not many fossils occur, and even these are pretty rare. The thickness of the triassic limestone is every where at least 1,000 feet, but it exceeds in places even 2,000 feet.

Sungnum.

Near the village Sungnum, where the Pin river changes its course from North to North-east, the carboniferous beds appear in considerable thickness, as has been previously mentioned. At Kuling the triassic rocks are in a peculiar position, quite conformably seen below, and with other similar foldings, of which the explanations can be proved by directly observed facts. Besides the extraordinary compressed forms, in which the fossils occur, are not opposed to this opinion.

Above Kuling.

Ascending the low hill above the village Kuling the strata can be traced with the greatest possible clearness. We come from the quartzites with *Sp. Moosakhailensis* upon the crumbling shales with *Spir. Keilhavii* and *Prod. semireticulatus*, and above these the first layer of limestone is a bed of about 6 inches in thickness, almost solely consisting of *Halobia Lommeli*. The next beds of the limestone are very remarkable from their being

so very much like to similar beds of the upper trias in the Alps, usually called by Alpine Geologists, '*Grossoolit-Mergel*' (great oolite-marl). They are light coloured concretionary beds of limestone, impregnated with much oxide of iron. The globular structure shews with particular clearness through thin veins of the reddish oxide. The beds are from 1 to 3 feet thick, and abound with Ammonites and other fossils, but it is exceedingly rare, that a single specimen in good preservation can be obtained. This quasi-concretionary limestone is very characteristic of the lower beds of the trias in Spiti, it can almost everywhere be recognized above the carboniferous beds; its total thickness varies between 50 and 100 feet. Passing towards the top of the hill above Kuling the *Halobia Lommeli* continues to be frequent, until the beds become very earthy, thin bedded limestones, which farther to North-east are very much contorted. I have not observed any kind of fossils in these thin-bedded limestones, but they seem to be still triassic.

Concretionary limestone.

Leaving this interesting locality we come, along the left bank of the Pin river, repeatedly upon triassic limestone, resting on the Kuling series, which appears in dome-form upheavements. The limestone is chiefly compact, black, and contains occasionally *Orthoceras salinarium*, *Ammonites Gerardi* and *fissicostatus*, a circular *Lima* and *fragments of bones*, probably belonging to some fishes. The contortions are on both sides of the valley very great, and extend locally even into the liassic beds above, although these are not usually much affected.

Left bank of Pin river.

Exactly the same succession of the triassic beds, as has been described at Kuling, is to be found above the carboniferous rocks East of Lilang. The limestone is very rich in fossils although the *Ammonites* are mostly very indistinct in the concretionary beds. *Brachiopoda* abound and are to be had in great quantities. This locality will be very often mentioned in the

East of Lilang.

Palæontological notes; it lies about two miles East of the village Lilang on the Lingti river, and is worthy of receiving attention from any subsequent traveller. Farther to East the limestone is seen to thin out gradually, the last remnants of it are seen on the distant hills for a few miles. In North-east direction the limestone must extend much farther, of which we have no certain idea, as the country is neither accessible from the Spiti side, (at least not without very great difficulties and very considerable expense), nor was it possible to enter the Chinese province Tso-Tso from any part.

To South-east the limestone thins out equally, and in the neighbourhood of the village Thabo it is seen only occupying the very tops of the mountains.

How far it extends in the southern direction we cannot form at present any correct idea. It seems to cross the Manirang pass, and the limestone on the Hangrang pass, which Dr. Thomson mentions as being the first met on the road along the course of the Sutlej, is probably triassic. It is of no use now to offer any farther suppositions, and we leave the question for the future, when it shall receive attention.

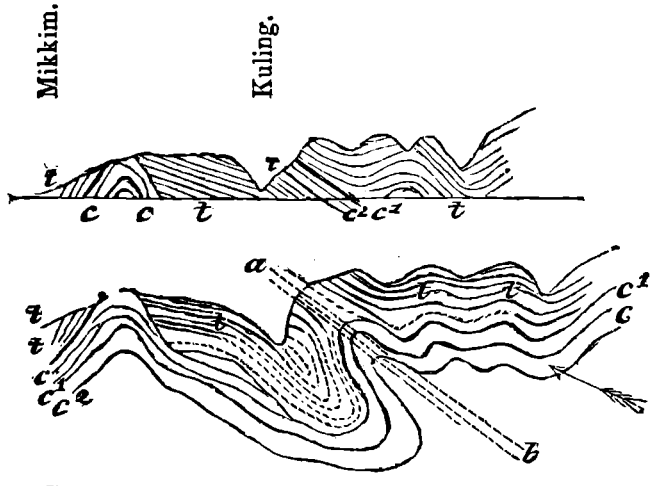
In North Spiti.

In the middle and northern portions of Spiti the triassic limestone is everywhere met with in the deep ravines and valleys, under the Tagling limestone. Along the northern declivities of the Pir-panjal range the limestones have always the same mineralogical characters, and contain the same fossils. The beds immediately above the carboniferous are nearly everywhere fossiliferous, and we could only repeat the same section from above Losar and the East of the Kunzum pass, which we have more fully described from Muth and Kuling. In the Northern part of Spiti the triassic beds are mostly compact and black, in which occasionally a *Halobia* or a fragment of an *Orthoceras* are met with. Their thickness decreases on this side of the Bara-latse range very consider-

ably, and amounts in places only to 100 or 200 feet. Contrary, however, to this the upper limestones increase very much in thickness.

The stratigraphical position of the Lilang limestones, appearing usually above the folds of the Kuling series, is nearly everywhere the same as previously mentioned. They become exposed with these in the deep valleys above the carboniferous rocks; and as all the strata contain very characteristic fossils the sections, as seen, must be explained by mechanical disturbances only. The accompanying woodcut, Fig. 2,

FIG. 2. SKETCH SECTION BETWEEN MIKKIM AND KULING.



c Carboniferous.
t Triassic.

represents the section from Mikkim to Kuling on a scale of 8 miles to an inch; it is the section, as it can be observed now on travelling along the left bank of the Para and Pin-chu. We have previously observed, that the carboniferous strata of the Kuling series consist alternately of shales or sandstones and of whitish quartzite. The upper white quartzites, which are seen East of Mikkim, must thin out farther towards the East, at least for a short distance, as indicated in the lower section. As there can be little doubt that the carboniferous rocks have been brought up by repeated wave-like foldings, we must presume the previous state of the section to have been something like the represen-

tation given. If we now let the lateral force act in the direction of the arrow, the effect would be not only a compression, but also a progression. West of Kuling a break is visible, in which a stream comes down from North-west and partly from North. The force, acting in the direction of the arrow, has caused a break along the line *a b*, and as the compressive force could not have any farther effect the progressive force could act with much greater result. In consequence of this the upper strata (shales and quartzites) have been slipped along the lower towards the West, as indicated by the dotted lines. The crushed state of the carboniferous fossils seems to be in favor of this opinion. We get in this way an explanation, how the Triassic beds (with *Am. Khanikofi*, an Ammonite similar to *Am. Johannis-Austriæ*, *Am. Thuillieri*, *Lima* conf. *Ramsaueri*, and *Halobia Lommeli*,) came below the carboniferous, which themselves show *no repetition* of the beds, as ought to be the case in a simple folding. I have preferred this somewhat lengthened explanation to one depending on breaks, repeated upheavements and denudations, because I believe it to be much nearer the truth and quite in accordance with other observed facts.

TRIASSIC FOSSILS.

The remarkable similarity and partial identity of the Himalayan Triassic fauna with that of the Alps has been already noticed by Mr. Salter in Col. Strachey's Palæontology of Niti, &c., 1865, Calcutta p. 55. Professor Suess of Vienna had also drawn attention previously to this similarity of the respective faunas. My previous studies of the Austrian fossils, and a collection which I brought to the country in 1862 aided me greatly in my determinations, and cleared up several doubts.

The following fossils belong, as has been noticed in the previous remarks, to the upper Trias only. The uniformity of the deposit and its enclosed fauna in all parts of the world is a very striking and interesting fact in the Geological history of our globe. The re-

searches of Dr. F. von Hochstetter in New Zealand,* and lately those of Mr. Whitney and F. von Richthofen in California† added greatly to our knowledge of this formation.

It was, I believe, Col. R. Strachey who, some years since, first separated the Triassic deposits in the great set of secondary limestones of the Himalayas, North of Kumaon. The descriptions of the fossils by Mr. J. W. Salter, although ready for publication in 1862, and known to many interested in the subject, have been only lately (March 1865) published. The notice of these and other fossils from different beds and of different age, gives tolerably satisfactory data for the conclusions of Col. R. Strachey. In Messrs. Schlagintweits' collection of Himalayan fossils, the descriptions of which have been partly‡ published by Professor Oppel in his "Palæontologische Mittheilungen, 1864," there exists great confusion as regard the formations to which the different species belonged. I know, from private correspondence only, that Professor Oppel suspected the different ages of the fossils but that he could not come to any certain conclusions, as Messrs. Schlagintweits' information was on this point unsatisfactory. A similar admixture exists also in Dr. Gerard's collection of Spiti fossils, which have been described in the Asiatic Society's Journal, Bengal, for 1863, by Mr. H. F. Blanford.

In referring several of the following fossils, which have been previously described as jurassic, to the Trias, I can only state that these alterations may be taken as being not entirely unjustified. Of course, I must remain responsible for them, but I may be allowed to state, that I have used my best efforts to avoid any confusion. No fossils have been accepted which have not been, or at least seen to be, picked up by my colleague F. R. Mallet or by myself. Where fossils from previous collections on good authority have been described, it will be always mentioned.

* Palcontologie von Neu-Seeland, (Novara expedition) Wien, 1865. *Prof. K. Zittel* Fossile Mollusken aus Neu-Seeland, p. 19, etc.

† Sillim. Am. Journ. 1864.

‡ Prof. Oppel having received notice of the present report of my survey, has kindly informed me, that he will stop his further publication of the descriptions of the Himalayan fossils, until my memoir will appear.

The known triassic fauna of Spiti is referrible to the following groups:

Echinodermata: crinoid stems, only.
Brachiopoda: 12 species.
Pelecypoda: 4 species.
Gastropoda: 3 species.
Cephalopoda: 18 species.
Vertebrata: Reptilian or Fish remains? (traces only).

Among 38 species of fossils we find 15 identical with those from the Alpine Trias.

I.—*Echinodermata.*

Only fragments of CRINOID STEMS have been as yet noticed at *Kuling, Muth, Lilang* and other localities. They seem to belong chiefly to *Encrinus cassianus* Laube, (Verhandlungen der k. k. geol. Reichsanstalt, Wien, 1864, vol. XIV., p. 207), a species which is very common at St. Cassian and other places in the Alps, and which has been for many years mistaken for the Muschelkalk-species *E. liliiformis,* Schlotheim. Mr. K. Laube's researches of last year have clearly shown the error of the universally accepted opinion.

II.—*Brachiopoda.*

Several of the Brachiopoda are described as new species, a few are left undetermined and referred to the nearest allied species. Of species identical with those from Europe only four are yet known, namely, *Athyris Strohmeyeri* and *Deslongchampsi, Rhynchonella retrocita* and *Rhyn. Salteriana,* n. sp. By far the majority of the specimens has been collected at Lilang on the Lingti river, North-east from Drangkhar.

1. SPIRIFER *n. sp.* A few miles west of Kuling, in the Pin valley, two specimens of a large-ribbed *Spirifer* have been found in the oolitic limestone. The species resembles much the carboniferous *Spirifer striatus.* The ventral valve has a deep sinus, and a very large triangular area, projecting nearly at a right angle from the hinge line; the deltidium is in two pieces, the fissure long, but narrow. The fold of the dorsal valve is on its greatest convexity distinctly double; this division, however, becomes obliterated towards the periphery.

Both our specimens of this, no doubt very interesting and probably new species, are insufficient to admit of its being named and described in greater detail.

2. SPIRIFER (SPIRIFERINA) *conf.* FRAGILIS, Schloth. (*Vide Alberti*, Uberblick über die Trias, 1864, p. 157).

Some imperfect specimens, but very like the Muschelkalk species, have been met with South of the village Muth, in the Pin valley. They differ only in having 7 to 9 ribs on each side of the fold, instead of the usual number of 6.

3. SPIRIFER (SPIRIFERINA) STRACHEYI, Salter. (1865 in Strach. Pal., p. 72, pl. 9, fig. 13).

The species occurs plentifully at Lilang: our specimens have usually a much longer hinge line, than is seen in Mr. Salter's figure, and are not so high. The number of ribbings on each side of the sinus varies from 5 to 8. The fold is sometimes very strong, and the dorsal valve very convex; however, among these variable forms, we possess others, which perfectly agree with the description and figures quoted above. The surface of the shell, when well preserved, is finely punctated, as is characteristic for the subgenus *Spiriferina*, d' Orb.

Col. Strachey found the first described specimens near the Rajhoti pass, North of Kumaon.

4. SPIRIFER (SPIRIFERINA) LILANGENSIS, Stol., Pl. III. fig. 4.

Sp. testa pinguis, transversaliter ovata, non auriculata, latior quam alta. Valvis convexis, plicosis: plicis simplicibus; jugo parum elevato, lato; valvæ ventralis sinu profundo; rostro valde prominente, parum incurvato; area triangulari; deltidio diviso; superficie inæqualiter granulosa.

The oval shape distinguishes this species readily from the former, the hinge line being less than the greatest width of the shell. Both valves are strongly convex; fold and sinus are simple; the former somewhat flattened, the latter comparatively deeper. On each side of the sinus are 6 to 8 ribs, simple and decreasing in strength towards the hinge line. Beak rather extended, the area projecting in nearly perpendicular direction from the dorsal valve, being accordingly

slightly concave to the beak; deltidium in two parts; fissure triangular, proportionately not very broad. The surface of the shell is distinctly granulated, the granulæ being unequal in size among themselves, and stronger than those of *Sp. Stracheyi.* Of transverse or concentric striæ of growth only a few are seen, and these at considerable distances from each other.

Locality: Lilang on the Lingti river; two specimens have been examined.

In form, but less in its ornamentation, the Spiti fossil resembles *Sp. Emerichi,* Suess, (Denksch. d. k. Akad. Wien, 1854, vol. VII., pt. II., p. 52, pl. 2, fig. 7) from the Kössner strata of the Alps.

5. SPIRIFER SPITIENSIS, Stol., Pl. III, fig. 5.

Sp. testa late-ovalis; valvis moderate convexis, costulis radiantibus, numerosis, ornatis; jugo vix elevato, parum protracto; rostro valde incurvo; fissura tringulari.

The form of the shell is broadly ovate or roundish rhomboidal, nearly quite as broad as it is high. The valves are moderately and nearly equally convex, covered with numerous radiating costulæ; the sinus and fold being very slightly marked. The ribs on the fold do not seem to be stronger than those on the rest of the shell. The hinge line is much shorter than the greatest width of the valves, and the beak is strongly prominent and incurved. The fissure is triangular, being partly covered by the umbo; the deltidial plates are not visible, they must, however, be very small; the ridges on the beak are not at all developed and the false area is scarcely marked.

Locality: Lilang on the Lingti river.

Besides the figured specimen we possess from the same locality another one, which is far more inflated, and the area, although of small size, is still distinctly marked. The beak is not so much incurved and approached to the umbo. The form, ribbing and the slightly expressed fold and sinus are identical. We merely intend by this remark to invite the attention of any subsequent traveller; the species, as indicated, may prove a distinct one, or it may be identical with *Sp. Oldhami,* Salter (in Strachey's Palæont., p. 72, pl. 9, fig. 12) from the same beds North of Kumaon; this latter species not having been observed as yet in Spiti.

6. RHYNCHONELLA MUTABILIS, *Stol.*, Pl. III. figs. 6-9.

Rh. testa ovate-rhomboidea, inflata seu depressa, variabilis atque nonnumquam deformis, radiatim costata: costis simplicibus, crassis acutisque, ad peripheriam multum fortioribus earumque terminationibus acute sinuatis. Jugo valde elevato atque prominente, 2.-seu 3.-costato; rostro elongato, prope recto; apice incurvo.

Shell sub-rhomboidal, ovate, either much inflated or somewhat depressed. It varies as well with regard to form as to its ornamentation, which consists of a few sharp ribs, disappearing towards the middle of the valves, but forming strong sinuosities at the periphery. The mesial fold is either very high, prominent, or in other cases scarcely elevated; it bears two or three (seldom four) ribs, which correspond respectively to one or two in the sinus. On each side of the fold there are two or three additional ribs, becoming considerably thinner towards the hinge line; in very few cases even a fourth lateral rib is marked. The rest of the shell surface is smooth.

The beak is sharply pointed, not very prominent or incurved, and on its ridges rounded. Foramen and deltidial plates are not clearly visible in any of our specimens, but the latter must certainly be very small. The figures 6-9 on Plate III, and the accompanying explanations, will give a better idea of the numerous variations, than it is possible to express in many words.

Of triassic allies it would be worth while to compare with our species *Ter. Johannis-Austriæ* (Klipstein, Oestl. Alpen, p. 211), and *Ter. semiplecta, Münster.* The descriptions and figures of neither give sufficient detail for comparison. Farther, the great resemblance of our species with the liassic *Rh. variabilis*, Schloth. *sp.* will, no doubt, be readily noticed, and as the amount of variation is in both very nearly the same, it is not easy to distinguish them at the first glance.

The far greater development of the area however, the sharp lateral ridges on the beak, and, in accordance with both, the large size of the deltidium, will help to recognize the liassic from the triassic species.

Locality: Lilang on the Lingti river; not rare.

7. RHYNCHONELLA THEOBALDIANA, Stol., Pl. III., fig. 10.

Rh. testa ovalis, trigona, lævigata, subinflata; sinu profundo atque lato; jugo vix elevato, ad peripheriam undulato, rostro incurvo, umboni valvæ minoris approximato.

This fine species has an ovate trigonal shape; the dorsal valve is somewhat more convex than the ventral, which has a very broad and deep sinus; the mesial fold on the former being, however, scarcely elevated above the convexity, flat, with three undulations at the periphery. From the fold the sides slope down rapidly, exhibiting each only one furrow and being prolonged as sharp prominent ridges beyond the convexity of the rostral valve. The beak is strongly bent upwards and closely impressed on the umbo. The foramen is elongated, lineal, but the deltidial plates are not visible.

The species bears some resemblance to *Ter. subacuta*, described by Count Münster from the triassic beds of St. Cassian (*vide* Münster's Beitræge, 1841, p. 55, pl. 6, fig 1.

Locality. The single specimen was found in 1861, at Muth in the Pin valley, by W. Theobald, Esq., Jun., of the Geological Survey of India.

8. RHYNCHONELLA SALTERIANA, *Stol.*, Pl. III, fig. 11-12.

Rh. testa sub-triangularis, inflata; valvis multice radiatim costatis; jugo parum elevato, lato, costulis septem ornato atque utrinque sulco profundo marginato; area magna; rostro prominente, umbone obtuso.

An ovate triangular and rather inflated shell, which is ornamented with numerous radiating ribs. Mesial fold is not much elevated, broad, bounded on each side with a deeper furrow and ornamented with seven straight ribbings. On each side of the fold there are about five additional ribs, which, in proceeding towards the periphery, slightly curve outward. The beak is rather prominent and incurved; its ridges are strongly developed, as well as those of the umbo of the dorsal valve and both together limit a flat and smooth elliptical area on each side, the median line of which shews usually slight undulations equally as the rest of the periphery of the valves. The umbo is obtuse.

The above description is derived principally from the figured specimen, which is the most perfect, and was found with all the other

species at Lilang on the Lingti river. This specimen and a few others, met with at *Muth* and *Kuling* in the Pin valley, resemble a good deal that species which has been determined by Professor Suess as *Rhyn. retrocita*, (*Vide* Salter in Strachey's Palæont. 1865, p. 71, pl. 9, fig. 11.) We possess another specimen which we rather believe to be much nearer to the true Alpine *Rhynchonella retrocita*. It would be impossible to admit the variations of this Rhynchonella to go so far, as to refer such essentially different forms to one species. There could hardly be quoted a single point of coincidence between them. There must be some mistake on this point. I have brought, from an excursion in the neighbourhood of Hallstadt in 1860, a few specimens of this Rhynchonella, and give a figure Fig. (12) of one of the specimens. They look very much like the white fossils from the Hierlatz beds on the Schafberg. However, as I have never visited this locality myself, I believe I must have got them somewhere near Hallstadt or Aussee in the triassic limestone. I cannot distinguish these Alpine specimens from ours. The species is allied to Professor Oppel's *Rh. rimata* (Zeitsch. d. Deutsch. Geol. Gesellsch, Vol. XIII, p. 542., pl. 12., fig. 2) from the Alpine Hierlatz-Schichten.

9. RHYNCHONELLA RETROCITA, (*Suess,*) *var.* ANGUSTA, *Stol.* Pl. III, fig. 13.

Rh. testa ovalis, sublævigata, valva dorsalis in medio ad peripheriam profunde sinuosa; valvæ ventralis jugo elevato; superficie radiatim minutissime striata; rostro parum prominente, deltidio diviso, foramine lineari.

Shell ovate, higher than broad; valves slightly convex, the surface covered with fine radiating striæ, which are visible on the cast. The beak is not very prominent, with distinct ridges bordering a very small and somewhat concave area on each side; deltidial plates not distinct. The point of the beak is not preserved on our specimen.

The dorsal valve is in the middle of its posterior extremity deeply indented towards the rostral valve, the greatest convexity of which runs along the medial line from the beak to the periphery. From this convexity the shell slopes down gradually to the lateral margins, an essential character of the original *Rh. retrocita*, Suess,

(*Vide* Denksch. d. k. Akademie, Wien, 1855, Vol. IX., pt. II., p. 29, pl. 1, fig. 10) from the Alpine upper Trias.

I hesitated long whether to identify our Himalayan form with the European, or to name it newly. As, however, I am well aware of the many variations of *Rhyn. retrocita*, and as the principal difference of our (single) specimen lies only in the oval form, it is no doubt preferable to regard it as a variety only. Further researches may possibly bring more material to our knowledge. The fine striæ, which are seen in our specimen, are not of much consequence. I do not exactly remember them in the European form, but I believe they do exist also on the casts. The prolongation of the mesial fold in our specimen is different from that of the Alpine originals, in which it is usually much more reflected and not prolonged at all. I have not been able to trace out the meaning of Fig. 9. on Plate 9 in Col. Strachey's Palæontology; the figure is very like our specimen, and may not Prof. Suess have intended this rather as identical with his *Rh. retrocita ?*

Locality: Lilang on the Lingti river; a single specimen as yet found.

10. ATHYRIS STROHMEYERI, *Suess, sp.*

Spirigera id. 1855. Denksch. d. k. Akad. Wien, Vol. IX., pt. II, p. 27, pl. 1, figs. 4-6.—1865, Salter in Strachey's Palæont., p. 70, pl. 9, fig 10.

Several very characteristic, inflated specimens have been met with at *Lilang*. As Mr. Salter has already remarked, the Himalayan forms are found often to be broader than figured by Suess; deformed specimens are also frequently met with, and these must have possessed that shape originally, not in consequence of mechanical pressure only. The species is not rare in other localities in Spiti, as near Drangkhar, Kuling, Khar, &c. Col. Strachey found his specimens near the Rajhoti pass, and the species is also very common in the Alpine limestone of the Hallstadt-strata.

11. ATHYRIS DESLONGCHAMPSI, *Suess, sp.*

Spirigera id. 1855, Denksch. d. k. Akad. Wien, vol. IX., pt. II., p. 26, pl. 1, fig. 3.

A single specimen has been met with at Lilang on the Lingti river, but it is very characteristic. On one side, where the shell surface is weathered off, the spirals are visible; they lie so, that their

apex is directed towards the angles formed by the sides and the posterior periphery of the valves, while the axis of the spirals of the former species is perpendicular to the width of the shell.

The species occurs in the North of Kumaon also, and accompanies the former there, as in the Alps.

12. WALDHEIMIA STOPPANII, *Suess.* 1860, Palæont. Lomb. 1 ser., p. 106, pl. 23, fig. 12-16.—Salter, in Strachey's Palæont, p. 71, pl. 9, fig 6-7.

The Himalayan specimens are nearly always less inflated than the European fossil from the Esino limestone. The mesial fold is distinctly developed only in the largest of our specimens, those equal in size to Prof. Suess' figure have the fold or sinus hardly marked at all. Most of our specimens are also somewhat more oblong. The other characters agree perfectly.

The species occurs plentifully in the Lilang limestone, and has been also found by Col. Strachey on the Rajhoti pass North of Kumaon.

III. *Pelecypoda.*

Not many species of this family have been yet found, and the few which occurred are not in a very satisfactory state of preservation. A little North of the village Muth in the Pin valley and near Kuling, thin beds of limestone occur, nearly exclusively composed of little bivalves, among which several have a striking resemblance to those known from the St. Cassian beds. *Arca impressa, Monotis lineata,* several of the ribbed *Aviculæ, Nuculæ, Carditæ,* and others seem to be represented. I am sorry that there was, during our survey, not sufficient time to devote more attention to these little fossils, and I can only bring them to general notice. There would not be much gained by quoting many names and leaving them uncertain. Of special interest will be found only the following:—

1. HALOBIA LOMMELI, *Wissm.*

Hörnes, in Denksch. d. k. Akad. Wien 1855, vol. IX., pt. II., p. 52, pl. 2, fig. 17.—*Posidonomia* id, *Stoppani,* Palæont. Lombard. 1860, p. 98, pl. 19, fig. 6 (7-11 ?)—*Halobia* id, *Zittel,* Palæont. von Neu-Seeland, Wien, p. 27, pl. 4, fig. 2—*Monotis* id, *Salter* in Strachey's Palæont. 1865, p. 68, pl. 9, fig. 1-2.

The Himalayan form is exactly the same as the Alpine, and does not show even such small variations as has been noticed in the

specimens from New Zealand and California. Beds up to 6 inches thick, nearly exclusively composed of this interesting species, occur at many places in Spiti. In quite similar beds it has been noticed farther to the east by Col. Strachey, and the same strata are well known to Alpine Geologists in Europe (at Bleiberg, Hallstadt,* Aussee, Ischel, etc.). I was rather surprised not to find even a trace of the usual associate of this species, the *Monotis salinaria*, Bronn; perhaps some subsequent traveller may be more fortunate!

2. LIMA *conf.* RAMSAUERI, *Hörnes.*

1855. Denksch. d. k. Akad. Wein, vol. IX, pt. II, p. 52, pl. 2, fig. 19.

We possess only one specimen, which measures 120 mm. in width and nearly as much in height, the thickness is 71 mm. This size exceeds greatly that of the usual Alpine forms, but there are hardly any other differences to be noticed. The form of the shell, the radiating and concentric striæ, the cordial shape of the lunula, which is hollowed out, agree perfectly with Dr. Hörnes' description and figure.

From Kuling in the Pin valley.

3. LIMA *n. sp.* Shell very thick, much higher than broad, rather depressed, with striæ of growth only. One specimen has been found at Lilang; it does not agree with any known species that I am acquainted with.

Another more circular *Lima* has been noticed East of Kuling, it does not shew any particular resemblance to known Triassic species, but its nearest ally is the liassic *L. scrobiculata*, Stol. 1861, in Sitzungsb. d. k. Akad. Wien, vol. XLIII., p. 199, pl. 7, fig. 10.

4. MYOCONCHA LOMBARDICA, *Hauer.*

1857. Sitzungsb. d. k. Akad. Wien, vol. XXIV., p. 559, pl. 6, fig. 1-6).

The specimens found at Kuling agree well with F. von Hauer's description and figures, especially with Fig. 4. loc. cit. The resemblance of the fossil to *Mytilus Esinensis*, Stoppani (1860, Pal. Lomb. p. 90, pl. 18, figs. 12-13) from the upper Trias of the Southern Alps, is well worthy of notice.

* The designation of the Alpine localities by Mr. Salter in Strachey's Palæontology is not always very correct.

IV. *Gastropoda.*

With the little bivalves previously noticed, there often occur also numerous *Gastropoda* of small size. I found at *Kuling* a fragment of a large *Chemnitzia*, one of the species, of which many are known from the Southern Alps, (Esino-limestone and dolomite.) At Lilang great numbers of the similar small *Turritellæ*, *Trochi* and others, figured by Münster and Klipstein, have been met with, but they are usually visible on the weathered surface only, while hardly a trace is to be noticed of them in the rock itself. I will mention for the present merely the following species:—

1. DISCOHELIX *sp.*

Only one fragmentary specimen has been met with at *Lilang*, but it distinctly belongs to this genus, (not to *Platystoma*, Hörnes.) The shell is smooth, quite symmetrical, resembling the Liassic *Dis. excavatus* (vide *Stoliczka* in Sitzungsb. Akad. Wein, 1860, vol. XLIII., p. 194, pl. 3, figs. 1, 2); the whorls are still more numerous and narrower. So far as I am aware this is the first notice of the genus Discohelix in triassic rocks. I have a few years back, described, in the paper quoted above, several species from the Alpine Lias, and also referred to the occurrence of many species in the Lias and Jura of Normandy.

2. PLEUROTOMARIA *conf.* BUCHI, *Deslongch.* Sitzungs. d. k. Akad. Wein, Vol. XLIII., p. 188, pl. 4, figs. 4, 5.

In alluding to the liassic species, which is well known to me from the Hierlatz-strata of the Austrian Alps, I do not at present intend more, than to recall the remarkable similarity of the triassic Himalayan fossil with the former. I found it myself on two localities in the triassic beds South of *Drangkhar* and East of *Lilang*. There is no mistake about the age of the rock; notwithstanding I confess, that I am unable to distinguish the two specimens (they are not quite perfect) from the species above referred to. Farther searches will probably clear up the doubt.

3. PLEUROTOMARIA STERILIS, *Stol.* Pl. IV., fig. 1.

Pl. testa depresso-conica, trochiformis; anfractibus paucis, convexis, ad medium sub-angulatis, spiraliter atque transversaliter striatis; fascia

sinûs angusta, infra medium anfractuum sita, utrinque lineis impressis marginata ; ultimo anfractu ad basim subrotundato ; basi subplana, vix striata ; umbilico magno profundoque ; apertura rotundate-rhomboidea.

The principal characters by which the present species is easily distinguished from other similar triassic forms, consist in the broad conica shape of the shell, the small number of sub-angular whorls, covered with transverse striæ of growth, interrupted on the sinus, and with other somewhat stronger striæ in spiral direction. The band lies on the perpendicular portion of the whorls, a little below the angular convexity of each ; it is very narrow, with the usual concave striæ of growth, and bounded on either side with a fine groove. On the basis of the last whorl the striæ become nearly obsolete ; umbilicus largely open.

Locality : Lilang on the Lingti river ; rare in the limestone East of the village, and seldom observed in other places in Spiti.

V. *Cephalopoda.*

The present number of known triassic Cephalopoda from Spiti amounts to 18, but there is every hope that it will be largely increased.

Three species of *Orthoceras* are all identical with Alpine forms from the upper triassic beds, namely, *Orth. salinarium, latiseptum* and *dubium,* Hauer. One species of Nautilus is described as new, but it is remarkably similar to *N. brevis,* Hauer. Of *Clydonites* two new species have been found. Of *Ammonites** twelve species are noticed ; five of them are European, namely, *Am. floridus, difissus, Gaytani, Ausseanus* and *Studeri ;* the rest have been previously described either by Prof. Oppel or Blanford (loc. cit.), and only two are designed as new. Besides these there are fragments of four different species of Ammonites, too imperfect to be named and described. One of these species is very like *Am. minimus,* Hauer (Sitzungsb. d. k. Akad. Wien, 1860., vol. XLI., pl. 2, figs. 1-4), and is probably identical ; it differs only in its greater size, which exceeds 2 inches in diameter. What appears strange is, that not a trace of *Am. Aon,* which is so

* My friend, Prof. *E. Suess* of Vienna, tells me in a letter of the 26th December 1864, that he will shortly lay before the Academy a paper on Cephalopoda, with regard to several points in the organisation of the shell and its connection with the animal. The "Globosi" will form, he says, a new genus *Arcestes* (*vide.* Strachey's Pal., p. 66). However, not being as yet aware in what way Prof. Suess will restrict or extend this genus, I had better not introduce it here now.

common all through the Alps in these rocks and also North of Kumaon, (from Col. Strachey's researches) has been as yet found in Spiti. No doubt farther enquiries will reward the observer. As regards Ammonites, I would only mention that there exist large numbers of some species in our collection, which have throughout a constant elliptical shape. F. von Hauer and others have already previously on several occasions drawn the attention to similar asymmetry: instances of which, I would quote from *Am. Gerardi* or *Am. Batteni:* not to be thought of as any accidental compression, because we have often exactly similar specimens from three or four far distant localities, and among them not one specimen which would give a regular spiral.

I. ORTHOCERAS, *sp.*

Besides the three species noticed farther on, I have to draw attention to a remarkably thin and many-chambered species, which occurs east of Lilang in the triassic limestone, and is probably new; but I have not been able to obtain any sufficient material.

1. ORTHOCERAS SALINARIUM, *Hauer,* 1846, Ceph. des Salzkammergutes, Wien, p. 42, pl. 11, figs. 6-8.

The species is easily recognized by its broad, distant and not very concave septa. It has been met with in Spiti at *Khar,* and *East of Kuling* in the Pin valley, at *Lilang* and West of *Losar.* The specimens are perfectly identical with those from Hallstadt.

2. ORTHOCERAS LATISEPTUM, *Hauer,* 1846, Ceph. d., Salzkammergutes, Wien, p. 47, pl. 11, figs. 9-10.

Only one fragment has been found at *Khar* in the Pin valley. The form of the shell, with the very small angle of the convergence of the sides, the distant septa with their strong upper excavation and the central sipho easily distinguish the species from *Orth. pulchellum,* Hauer, (1850, Haidinger's Abhandlg. p. 1, pl. 1, figs. 1-3). Our specimen, being a cast only, does not exhibit the fine transverse striation noticed by F. von Hauer.

3. ORTHOCERAS DUBIUM, *Hauer,* Haidinger's Abhandlg. Wien, p. 260, pl. 7, figs. 3-8.

Several specimens have been obtained at Lilang, the largest of 150 mm. They agree well with specimens which we possess from Hallstadt. Only the septa are in our specimens usually not so distant, the

width being greater than the height; this, however, is a character of considerable variation, as noticed by von Hauer, loc. cit. p. 261. The fine striæ which, according to Hauer's observations, are sometimes visible on the interior of the shell, are not present on our specimens, but the thickness and smoothness of the exterior layer of the shell is quite identical with the Alpine forms.

II. Nautilus.

4. NAUTILUS SPITIENSIS, *Stol.* Pl. IV., fig. 2.

Naut. testa discoidea, parum involuta ; superficie reticulata ; anfractibus paucis, sub-angulatis, lateraliter complanatis ; dorso convexo, lato ; septis numerosis ; suturis simplicibus, lateraliter concavis, interne lobatis. Siphunculo eccentrico, prope marginem superiorem posito.

Proportions calculated from figured specimen (whole diameter being considered as 1.00) in diameter of ...	40 m.m.
Outer whorl : whole diameter	0.42
Width of umbilicus : ditto	0.35
Thickness of section : height	0.82
Distance of the siphuncle from the inner margin of the septum : its height	0.60

Shell discoid consisting of only two whorls, which are not very involute, leaving a large umbilicus perforated in the middle. The section of the whorls is sub-angular, these being flattened at the sides and slightly convex on the back. The surface of the shell is covered with fine reticulate striæ, of which those in transverse direction are somewhat finer, forming on the outer periphery a deep sinuation to backwards. The septa are numerous; the sutures simple, concave on the sides, nearly straight on the back and with a small lobe on the inner margin of each septum. The siphuncle is eccentric nearer to the outer region, being placed at about one-third distance from the interior margin.

Locality : Lilang on the Lingti river; the figured specimen is the only one which has been as yet noticed. Were it not for the position of the siphuncle, it would be impossible to separate the present form from *N. brevis*, Hauer (1860. Sitzungsb. d. k. Akad. Wien. vol. XLI., p. 121, pl. 2, figs. 5-8) from the Alpine Trias. Should farther discoveries prove, that the position of the siphuncle is so far variable as to become

dorsal, the separation would be inadvisable and moreover unnecessary. I may just remark, that I have myself observed among cretaceous Nautili variations in the position of the siphuncle in different stages of age.

III. Clydonites, Hauer.

5. CLYDONITES OLDHAMIANUS, *Stol.* Pl. IV., fig 4.

Cly. testa globosa, involuta, transversaliter subcostata; costis continuis atque divisis. Suturis lateraliter (usque ad umbilici marginem) quadri-lobatis, lobis cuspidatis, sellis rotundatis, alternatim minoribus.

The globular form and the larger umbilicus distinguish this species easily from *Cly. ellipticus*, Hauer, (1860, Sitzungsb. d. k. Akad. Wien., vol. XLI., p. 16, pl. 5, figs. 8-14). The ribs divide repeatedly from the umbilicus and are coarse. The sutures have four lateral lobes on each side, so far as they are visible, up to the edge of the umbilicus; they are sharply pointed and unequal among themselves: the saddles are simply rounded and alternately longer and shorter. On the whole the sutures are equally and similarly formed to those of *Cly. ellipticus*, but the latter are more numerous and the lobes are all equal in length.

Locality: Lilang on the Lingti river; a single specimen only has been as yet found; it is not perfect.

6. CLYDONITES HAUERINUS, *Stol.* Pl. IV., fig. 3.

Cly. testa sub-globosa, lævigata; umbilico aperto; ultimo anfractu eccentrico, aperturam versus prolongato; dorso rotundato, in medio anfractuum inferiorum sulcato; suturis lateraliter trilobatis, simpliciter sinuosis.

Shell sub-globose, somewhat laterally compressed, thickest round the umbilicus, which is open and becoming larger on the last whorl. The surface is apparently smooth, only covered with very fine striæ of growth. The inner whorls shew three distant sulcations in one circuit, indicating the previous positions of the mouth, on the middle of the back they are provided with a slight groove, which disappears on the last, or, probably more correctly on the body-whorl; the striæ are seen falcated on this groove.

The last whorl is somewhat prolonged and becomes eccentric. The aperture is not preserved on the figured specimen, but on another specimen it is seen simply extended with a deep furrow close

to its margin; quite similarly formed as in *Cly. ellipticus*, Hauer, (1860. Sitz. Vienna Akad. vol. XLI., p. 128, pl. 5, figs. 8-14), which our species resembles in its general form.

The sutures are trilobate on each side, and simply sinuated as in *Cly. costatus*, Hauer (ibid.); the lobes and saddles are roundish.

Locality: Lilang on the Lingti river; only two specimens have as yet been found.

I feel much satisfaction in naming the present species after our distinguished palæontologist *Franz Ritter von Hauer*, of the Austrian Geological Institute. His labours in tracing out the fauna of the Cephalopoda of the Alpine formations do not need to be mentioned, but he was the first who, in accordance with the newer and more uniform system of classification of the Mollusca, suggested a separation of the Cephalopoda into more numerous genera, a system so greatly objected to by many palæontologists, and yet so much desired by others, who endeavour in their researches to arrive at conclusions consistent with those of the classifying Zoologist.

IV. Ammonites, Brug.

7. AMMONITES FLORIDUS, *Wulfen, sp.*

1847. *Hauer* in Haidinger's Abhandlg. I., p. 22, pl. 1, figs. 5-14; —1865, *Salter* in Strachey's Palæont., p. 61, pl. 6, fig. 1, and pl. 8, figs. 1-3.

The sutures of our Himalayan forms exihibit in the dorsal lobe some slight difference from those of the Alpine species figured by *F. v. Hauer*; the specimens are otherwise undistinguishable, as noticed by Mr. Salter.

We found the species at Lilang on the Lingti river in Spiti, and it had been previously observed on the Rajhoti pass North of Kumaon by Col. R. Strachey.

8 AMMONITES JOLLYANUS, *Oppel.*

1864. Palæont. Mittheilungen, p. 271, pl. 75, fig. 4.

The interrupted depressions on or near the middle of the sides are very much like those of *Am. floridus*. The umbilicus is usually a little larger than represented in Prof. Oppel's figure, but it is always very shallow. The whorls are numerous; five inner volutions being exposed in one of our specimens, which does not exceed in size the

figure above referred to. With regard to this character it is very like *Am. planodiscus, Salter* (Strachey's Pal., p. 63, pl. 8, figs. 5-6), which may be only a young specimen of *Am. Jollyanus.*

The sutures are very exactly drawn in Oppel's figure.

The species was first found by the Schlagintweits at Kuling in the Pin valley, in which locality I observed it myself. It occurs at Muth oftener than any other fossil, and one of the largest specimens, brought in 1861 by Mr. W. Theobald, measures 180 mm. in diameter. On this specimen the last whorl represents exactly the same compressed and cuspidate section as in *Am. floridus.* The sutures, which before had only a resemblance, become also perfectly like in both. Were it not for the total involution of the last named species, nobody could distinguish fragments of outer whorls of *Am. Jollyanus* from those of equal size of *Am. floridus.* To the many variations already traced out in *Am. floridus* several more may be added in time, when we have procured sufficient materials. In such cases especially, it becomes clearly visible, that the inquiry into a species is by no means completed by giving it a specific name.

9. AMMONITES KHANIKOFI, *Oppel.*

1864. Pal. Mittheilungen, p. 275, pl. 76, fig. 4.

The lateral ribs undergo a good many variations; they are stronger and less numerous on the outer than on the inner half of the shell. However, even the former (those on the outer half) are sometimes twice as numerous as in Oppel's figure. On the middle of the sides, where the two portions of the lateral ribs join together, there are sometimes small tubercles formed at short distances from each other; they are not constant even on one and the same specimen, and do not certainly indicate a new form. If this is to be the principal character of Dr. Oppel's proposed new species *Am. propinquus,* (ibidem, p. 275, non *Am. propinquus,* Stoliczka, 1863, Pal. Indica, 3. ser., p. 23, pl. 30, figs. 1-2), it cannot be regarded as sufficient.

The umbilicus is sometimes very narrow, in other even smaller specimens larger. The whorls have usually their greatest thickness round the umbilicus, as noticed by Prof. Oppel.

But exceptions to this are not uncommon, and the shell is here sometimes more depressed than in the middle of the whorls. If a large

specimen can be spared so as to be broken, for examination, all these variations can be very often observed on one and the same specimen.

The sutures are clearly visible in Prof. Oppel's figure. In young specimens the saddles are perfectly rounded, as in *Ceratites;* growing larger, they become slightly and gradually more undulated and incised. Our largest specimen measures 75 mm. and consists still of air-chambers only.

The species has been observed at Kuling and at Muth ; at the first named locality and in Ngari Khorsum it was also collected by the Schlagintweits.

10. AMMONITES GAYTANI, *Klipstein.*

1843. Oestliche Alpen, p. 110, pl. 5, fig. 4.—F. v. Hauer in Haidinger's Abhandlg. 1847, I., p. 266, and 1850, III., p. 17.)

We possess only one fragmentary specimen from *Kuling,* it shews the flattening of the sides and of the back very clearly, and cannot be mistaken for *Am. subumbilicatus,* Bronn, as noticed by F. von Hauer, loc. cit.

Mr. Salter (in *Strachey's* Palæont., p. 65, pl. 7, figs. 7-8) refers to this species a few specimens from the Rajhoti pass. They may belong to this species, but the sutures figured on his plate 7 (fig 8 , c.) exhibit many differences both from our specimens and from the Alpine originals.

11. AMMONITES DIFISSUS, *Hauer.* Pl. V., fig. 4.

1860. Sitzungsb. d. k. Akad. Wien, XLI., p. 144, pl. 4, figs. 11-13).

The Spiti specimens, found at *Kuling* and *Lilang,* are quite identical in form and ornamentation with the Alpine. The two transverse furrows, indicating stages of growth, are not so strongly marked in most of our specimens, but they are seen disappearing towards the middle of the back in exactly the same way as mentioned by Hauer. The lobes have not been as yet traced in the Alpine specimens, and we give, therefore, a figure of them from one of our specimens; it may serve for comparison in future.

Col. Strachey found the species previously on the Rajhoti pass North of Kumaon.

12. AMMONITES AUSSEANUS, *Hauer.*

1847. Haiding. Abhandlg. I., p. 267, pl. 8, figs. 6-8.

Several specimens of different size have been met with at Lilang, and are perfectly identical with those known from the Alpine Trias. Three or four transverse furrows at short distances are distinctly visible, the shell is otherwise smooth. On the Rajhoti pass, North of Kumaon, it has been observed by Col. Strachey. (*Vide* Strachey's Palæont., p. 65, pl. 7, fig. 2, and probably fig. 4 too).

13. AMMONITES GERARDI, *Blanford.*

1863. Journ. As. Soc. Beng. p. 132, pl. 2, fig. 6, 1864.

1864. *Am. cognatus*, Oppel, Pal. Mitth., p. 285, pl. 81, fig. 3.

Both the existing figures by Messrs. Blanford and Oppel are taken from casts, and are not very characteristic, although so far sufficient, as to enable the species to be recognized. The transverse ribs, which on well preserved specimens (unless very young) are always very clearly visible, have their greatest thickness on or about the middle of the sides, and become thinner towards the umbilicus and towards the back. The number of ribs is usually from 16 to 18, and there are sometimes thinner ribs or striæ intermediate between them, as indicated in Prof. Oppel's figure. The greatest thickness of the whorls is round the umbilicus, which is very deep with perpendicular walls. The species attains a large size; one of our specimens from Kuling measures 125 mm. Specimens of elliptical shape are usually met with, having perhaps retained their original form, and not being only disfigured in consequence of lateral pressure of the rock.

Am. Gerardi is one of the most common triassic fossils in Spiti, it has been observed at Muth, Khar, Kuling, Silang, Lilang and East of the Kunzum pass. *Dr. Gerard's* original specimens must have been collected somewhere near Drangkhar, and Messrs. Schlagintweit found the species in Ngari Khorsum at Shangra, East of Puling.

14. AMMONITES MEDLEYANUS, *Stol.* Pl. IV., fig. 5.

Am. testa globosa, lateraliter compressa, sublævigata, prope peripheriam una serie tuberculorum ornata; dorso rotundato, transversim multice costato, costis in lateribus sub-obsoletis; umbilico angustissimo, apertura ovate-elongata. Septis lateraliter quinque lobatis, sellis uniforme bipartitis, earumque ramulis brevibus, subfoliaceis, lobis angustissimis atque profundis.

Proportions taken in diameter (considered as 1.00) of			.. 95	m.m.
Outer whorl : whole diameter	...	...	... 0.53	
Width of umbilicus : ditto	...	...	... 0.10	
Greatest thickness of section : height		...	... 0.78	

Shell sub-globose, laterally compressed, thickest round the umbilicus, sloping gradually from this to the outer periphery, the edge of which is ornamented with a row of tubercles. Only slight ribbings are seen on the sides, although it seems probable, that they were more strongly marked on the preserved surface of the shell. The back is roundish and crossed by numerous short costæ, which are slightly bent forward. The aperture is elongated ovate, much indented by the preceding whorl; umbilicus very small.

The sutures are laterally five-lobate; the saddles are all uniformly divided, bipartite, with short phylliform branches, and much broader than the lobes; the first lateral lobe is the longest, and the others diminish gradually in size towards the umbilicus.

The species is one of the interesting compressed Globosi, of the form of *Am. Studeri*, Hauer, *Am. Dontianus*, Hauer, and others.

The single figured specimen, the only one yet known, was in the collection of the Thomason College at Roorkee, and was, with a great number of other Spiti fossils, putat our disposal by Major J. G. Medley, R. E., Principal of the College. These fossils were those collected by Captain Hutton, and subsequently purchased for the college with his other collections. It is no doubt a triassic Ammonite, and judging from the matrix, I would believe it to be from Kuling in the Pin valley.

15. AMMONITES STUDERI, *Hauer.*

1857. Sitzungsb. d. k. Akad. Wien, XXIV., p. 146, pl. 1, figs. 1-4.

The identity between the Himalayan and European triassic fossil does not require much explanation more than referring to *F. Hauer's* excellent description and figure. I will mention only a few peculiarities. The number of transverse ribs amounts in our specimen to 15 only; in proceeding towards the periphery they curve slightly backward, becoming nearly obsolete or at least less distinctly marked. On the back, which is rounded, there is clearly a tendency to recurve forwards visible. Through the striæ of growth, which on the well

preserved shell are of considerable strength, this flexuous bending of the ribs can be followed without difficulty. As regards this point *F. von. Hauer* refers justly to the similarity of this species with *Am. Dontianus*, Hauer. (Denksch. d. k. Akad. Wien, II., p. 116, pl. 19, fig. 6) also a triassic species from the Alps.

The sutures of our specimen agree perfectly with *Hauer's* figure.

Locality: Muth in the Pin valley, rare.

16. AMMONITES THUILLIERI, *Oppel.*

1863. *Ceratites? Himalayanus*, Blanford, Jour. As. Soc. Beng., pl. 133, p. 2, fig. 7, (non *Am. Himalayanus*, D'Orb. Prod. I., p. 332).

1864. *Ammonites Thuillieri*, Oppel, Palæont. Mittheilungen, p. 277, pl. 77, fig. 3. (? Ibidem *Am. Voiti*, Oppel, p. 276, pl. 77, fig. 1, & *Am. onustus* Oppel, p. 277, pl. 77, fig. 2.)

1865. *Ammonites Blanfordi*, Salter, in Strachey's Palæont., 1865, p. 66, pl. 6, fig. 2, (non *Am Blanfordianus, Stol.* 1863, Pal. Indica, 3. ser., p. 46, pl. 26.)

The ornamentation of this species is generally well marked and characteristically shewn in *Prof. Oppel's* figure of *Am. Thuillieri.* Blanford's original figure is too indistinct, taken from a water-worn cast. The number of lateral ribs, which are always somewhat flexuous, amounts usually to 24, and many of them become bipartite on or about the middle of the sides. The tubercles along the edge of the umbilicus are either well marked, and remain so in every size of the species, or they disappear gradually altogether. The same thing takes place with the tubercles on the edge of the back. On some specimens they are very distinctly marked, while on others they never become developed, and the ribs form slight prolongations of the back. The thickness of the whorls and the size of the umbilicus are not very variable, although the former loses much in its appearance, when the ribs are thinner. Young shells possess a roundish keel, which becomes obsolete with advancing age; the back remains, however, always convex and somewhat elevated. The saddles of the sutures are perfectly rounded in the first stages of growth and become gradually divided into short foliations. The largest of our specimens from Lilang measures 120 m.m.

Am. Thuillieri is common all through the triassic rocks of Spiti; the best specimens are those from Kuling. The variations, which I have previously noticed, can be sometimes observed on one and the same specimen. I have broken for that purpose several, and, so far as I can judge, cannot admit, that any of the variations noticed indicate different species.

The original specimen of Prof. Oppel's *Am. Thuillieri* was found at Muth, where I have collected it myself.

Another specimen was brought by the Messrs. Schlagintweit from East of the Kunzum pass, and this one Prof. Oppel names *Am. Voiti.* There seems to be, however, very little chance of its being a different species. I have observed *Am. Thuillieri* myself at or near the same locality (3 miles West of Losar), although I have not found a specimen exactly like to *Am. Voiti.* A glance on *Prof. Oppel's* figure shews a difference from the type in the smaller size of the umbilicus and somewhat more compressed whorls, but neither of these exceeds the limits of variation, which we observe among our specimens. The direction and number of ribs are in both of Dr. Oppel's figures the same, and equally are the divisions of the sutures perfectly identical.

With regard to *Am. onustus*, Oppel, I can only regret, that such fragments are thought worthy of specific names. I cannot distinguish it from similar waterworn fragments of *Am. Thuillieri* in our collection. *Dr. Oppel's* remark, that the indentation in the section (fig 2. b. loc. cit.) may be too small, is most probably quite correct. The more distant lateral ribs are not sufficient to indicate a new species.

Am. Blanfordi, Salter, is a similar fragment, like *Am. onustus;* the ribs and tubercles are somewhat better preserved on it, but it does certainly not belong to a new species.

Somewhat more doubt exists as regards *Am. Winterbottomi*, Salter, (in Strachey's Palæont. 1865, p. 63., pl. 7, fig. 5) from the triassic limestone of Ngari. *Mr. Sowerby* was in this case probably more correct, when he marked a slight keel in figures b and c (loc. cit.), although Mr. Salter denies its existence distinctly. If a keel is really present, then we are, I believe, very nearly able to pronounce its identity with *Am. Thuillieri.*

After these remarks on the Indian materials, I may be allowed to allude to their greatest ally from the Alpine Trias of Europe, namely *Am. binodosus*, Hauer, (Denksch, d. k. Akad. Wien, vol. II., p. 114, pl. 19, figs. 1-4). A comparison of the Indian fossil with F. von Hauer's original specimens, which served him for examination, would no doubt be very desirable. The resemblance to *Am. Luganensis*, Merian, (F. von Hauer in Sitzungs b. d. k. Akad. Wien, 1855, vol. XV., p. 408, pl. 1, figs. 1-2) is also worthy of notice. The last of the two species just named has a keel, the former none.

There will, I hope, be no difficulty in settling many points of difference about the Himalayan species, as good material is in the hands of two of our best palæontologists in Europe. I have retained the name of the best figured specimens of Professor Oppel, *Am. Thuillieri*, as D'Orbigny's name *Am. Himalayæ* relating also to a Himalayan species (which D'Orbigny seems to have seen in *Sir R. Murchison's* collection,)* would possibly lead to collision with *Am. Himalayanus*, Blanf., which name would otherwise have priority.

17. AMMONITES MALLETIANUS, *Stol.* Pl. V. fig. 1.

Am. testa discoidea, subelliptica; anfractibus numerosis, subrotundatis, lateraliter costatis: costis crassis, circiter 26 *in uno circuitu, simplicibus, nontuberculatis. Dorso angustato, (convexo atque lævigato; umbilico magno, ad margines abrupto; apertura) ovali, postice cordata. Suturis lateraliter trilobatis, multice dissectis, sella dorsali parva, lobo laterali primo longissimo, tripartito: ramulis sellarum subfoliaceis; suturis auxiliaribus trilobatis, inæqualiter divisis.*

Proportions calculated from the figured specimen

(diameter being considered as 1.00) in diameter of				...	102	mm.
Outer whorl :	whole diameter	...	...	...	0·31	
Width of umbilicus :	ditto	...	...	...	0·47	
Thickness of section :	height	...	...	...	1·09	

The shell consists of numerous rounded whorls, which are involute, for about half their width leaving a large umbilicus with steep walls. The greatest thickness of the whorls is near the edge of the umbi-

* If the specimen exists, there may be some chance to get D'Orbigny's name a signification, but otherwise not. It refers probably to *Am. biplex* or *Braickenridgii*, Sow, or any other Ammonite of the "Planulati."

licus, and the shell slopes from here gradually towards the outer periphery. On the sides there are about 26 short ribs to one whorl; thick, but not much elevated, without any tuberculations, and disappearing towards the back and the umbilicus. The section of the whorls is ovate and cordate, the back being roundish.

The sutures have only two lateral tripartite lobes; the dorsal saddle is very small, and all have numerous phylliform branches; the first lateral is of all the lobes the longest. The auxiliary sutures are unequally subdivided, except the first, short but broad auxiliary saddle, which seems to have its bipartition regularly on or close to the edge of the umbilicus.

The species has a remote affinity to *Am. modestus*, Buch.; I am not aware of any other known form like our Himalayan species. It is named after my friend, F. R. Mallet, of the Geological Survey of India, my companion during our survey in 1864. Having previously visited Spiti in 1861, Mr. Mallet was able in several instances to facilitate the progress of our work.

Locality: Lilang on the Lingti river; the figured specimen is the only one as yet known.

18.—AMMONITES BATTENI, *Strachey.* Pl. V. fig. 2., Pl. VI. fig. 1.

1865, Palæont., Pl. XI, fig. 2, ibidem, p. 64, Pl. VI, fig. 4.

Am. testa discoidea, oblonga; anfractibus numerosis, lateraliter valde compressis, sublœvigatis interdumque prope umbilicum subcostatis, parum involutis; dorso rotundato, non carinato; umbilico magno, subplano; apertura elongate-compressa. Suturis lateraliter bilobatis, numerosissime atque profunde incisis; lobo dorsali brevi et lato, lobis lateralibus longioribus, inœqualiter tripartitis; sellis latis, prope tripartitis, ramulis subfoliaceis; suturis auxiliaribus multilobatis, umbilicum versus oblique descendentibus atque gradatim minoribus.

Diameter of largest specimen from Muth ... ... 350 mm.

Length of the shell : width, *or*, longer : shorter diameter ... ... *1.24 to †1.30

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* Specimen figured on Plate V., fig. 2.

† Plate VI., fig. 1.

Proportions calculated from figured specimens (the whole diameter being considered as 1.00) in the longer diameter of	68	„	1.40
Outer whorl : whole diameter...	0.25	„	0.32
Width of umbilicus : ditto	0.57	„	0.40
Thickness of section : height	0.58	„	0.44

The two figured specimens, of which the smaller has a greater number but somewhat less involute whorls, may be accounted as the principal varieties of this species. All our specimens (9) have the peculiar elliptical shape, although they come from three different localities. This form is therefore not accidental, but characteristic. The surface of the whorls is either smooth or bears sometimes short transverse ribs, which disappear towards the back. Laterally the whorls are always strongly compressed, higher and somewhat more embracing when less numerous, (fig. 1, pl. 6.); thicker and less involute when there is a greater number of them present, (fig. 2, pl. 5).

In the ornamentation of the shell and in the divisions of the sutures the varieties are perfectly identical. There is a broad, but short dorsal and two lateral lobes, of which the first one is the longest; they are unequally tripartite; the dorsal saddle has longer branches on the side of the siphuncle, and is, like the next lateral on its upper termination, unequally tripartite; all the branches are approaching to phylliform. The auxiliary lobes are numerous and descend obliquely towards the umbilical suture, similarly as in *Ammonites* of the cretaceous group "*Ligati.*"

Mr. Salter noticed a fragment (loc. cit., p. 64) of this species, but regarded it justly, as insufficient to name. A second fragment was figured among jurassic fossils by Col. Strachey on Plate XI and named below *Am. Batteni.* Mr. Blanford tells me that, so far as he can remember the fragment, it agrees quite with our specimens, but that he found it much too imperfect, and has therefore omitted any farther notice of it in his descriptions. I have, in consequence of this, retained Col. Strachey's provisional name. The species must have been only accidentally mixed with other jurassic fossils.

Localities: Muth, Kuling in the Pin-valley, Lilang on the Lingti river.

VI. Vertebrata.

Mr. Theobald found in the triassic beds East of Kuling a bi-concave vertebrum, and I got a few pieces of other bones in probably the same locality in the Pin valley. The vertebrum is hollowed out in the middle. It is impossible to say at the present, whether these fragments of bones belong to Reptiles or fishes even. Col. Strachey tells me, that he found a number of *fish teeth* in the triassic beds North of, or somewhere near, the Niti pass, but that they have been lost in some way, and he has not been able to recover any of them. We may, therefore, get in time some more information about triassic fishes from the Himalayas.

Section 2.—Rhœtic.—Para-limestone.*

In Northern Spiti there is above the Trias a thickness of some hundred feet of limestone, which, according to its fossils, seems justly to be called by the above name, as representing this Alpine formation in the Himalayas. The Para-limestone does not exist in the southern part of the Spiti valley, (above the Trias and below the Tagling limestone,) or we must have failed altogether to trace it out. Certainly it does not exist here with the characteristic bivalves, if it is to be found in reality, which I do not intend to deny. Traces of the Para-limestone are to be met with in the Parang section, but I remember having seen it, only in a few loose blocks, ascending the Pass towards the camp Bhaonrhochan, and I have therefore not noticed it in the section. It cannot be more than a few feet in thickness, if compared with the thousands of feet of the other limestones, in the North-western portion of Spiti, and not far to the West from the Parang road, the Para-limestone is well developed. It is a black, in some beds very earthy and strongly bituminous, limestone, which does not effervesce, or hardly effervesces at all, with acids. In the Alps this kind of magnesian limestone is generally called *dolomitic limestone*. It has a fine granular structure if compact, and breaks into small angular pieces, or usually, if thin-bedded, it is earthy. Where the Tagling stream (Lagudarsi river) joins the Spiti river, the thickness of the Para-limestone amounts to about 700 feet, its position above the Trias and below the Tagling limestone is here undoubted, and its mineralogical characters are quite different from those of both the other limestones. The fossils contained are *Megalodon triqueter*, *Dicerocardium Himalayense*, several species of *Chemnitzia*, of the character of those from the Esino-dolomit, and *Neoschizodus*. Towards the South the Para-limestone is seen decreasing in thickness, and probably disappears near the village Ki, or South of

* I mean to apply this name to the beds with *Megalodon triqueter*.

Kibber, altogether, but I did not follow it in this direction. In the western part of the Spiti river towards Losar it thins out gradually, and opposite to this village, to the North, it is seen only near the tops of the hills of about 100 to 200 feet in thickness. Towards the Tagling pass the thickness of the limestone without doubt increases (at least partially), and amounts probably to more than 1,000 feet on the other side of the Baralatse range in the Para valley. As it is here so very extensively and characteristically developed, I have adopted for this limestone a name from the river Para. I shall say a few words in the general summary in justification of the name *Rhætic*, and farther as regards its relation to other formations.

RHÆTIC FOSSILS.

The few fossils, which have been just now referred to, do not all permit a very accurate determination, and I would mention particularly, and as characteristic, only two; one is *Megalodon triqueter*, Wulf., a common Rhætic fossil in the Alps, and universally known as the "Dachstein bivalve;" the second belongs to a genus only newly established, and is specifically allied to a species from the same beds in the Southern Alps; a *Dicerocardium* allied to *Dic. Curionii*, Stoppani.

DICEROCARDIUM HIMALAYENSE, *Stol.* Pl. VII.

Dicer. testa magna, cordiformi, umbonibus valde protractis, externe subcarinatis atque contortis; superficie concentrice-crasse-lamellosa.

A cordiform, large bivalve with very much extended and somewhat spirally turned umbones; its form is that of a reversed cone, the basis of which is bordered with a rounded edge, which runs all along the outer side of the prolonged umbones. The hinge does not exhibit, so far as seen on our specimens, any particular teeth or grooves; it must be very similarly formed to that of *D. Curionii*, Stoppani. The surface is only covered with coarse, lamellar, ribs and sulcations of growth. The shell has a very great thickness, especially at the umbones, which consist, to a considerable extent towards their terminations, of a solid mass of shell. This latter has a spathic fracture, resembling much that of fossil Echinoderms.

The genus *Dicerocardium* has been only lately (1864, Pal. Lombardie 3. ser. 14-19, p. 248) published for the first time by Abbé Stoppani. The author describes, from the beds of *Megalodon triqueter*, Wulf. (*Megal. Gümbelii*, Stopp.), two species, large *Diceras-like* bivalves, which he amply illustrates; *Dic. Jani and Dic. Curionii.* The former is by much more slender than our Himalayan species, and exhibits besides many other differences. *Diceroc. Curionii* is, however, very like ours. The much coarser ribbing, more prolonged umbones, and the want of a special keel on their outer edge may separate the two forms, so far as Stoppani's representations allow a decision.

Locality: Two (one of which is only a half) specimens have been obtained East of the village *Chiote* in the North-west part of Spiti, but the specimens (and probably more than one species) are innumerable all through the Rhætic limestone in Northern Spiti, and in the Southern districts of Rupshu.

MEGALODON TRIQUETER, *Wulfen.* 1793.

1862. Gümbel in Sitzungsb. d. k. Akad. Wien, Vol. 45, pp. 325, etc.

Specimens of different size up to one foot in diameter occur in the Para-limestone in the North-western parts of Spiti and in Rupshu. I got from the Para valley two specimens, which leave no doubt about their identity with the Alpine forms. The specimens are quite different from any young ones of Dicerocardium.

Stoppani, in the last part of his publication of the Palæontologie Lombardie, which we have received in Calcutta, (3 Ser. 14-19), proposes on pp. 219-220 to abolish the old signification of the species altogether and to adopt a new name, *M. Gümbelii*, Stopp. If M. Stoppani could change all the papers in which the old signification of *Cardium triquetrum* has become familiar, there would be less objection to his well intended proposition, supposing that all other conchologists agree in this new treatment of palæontological literature. When Mr. Gümbel's paper on the "Dachstein-bivalve" was published, there were, I believe, very few palæontologists, who, after looking through that carefully executed work, did not think the matter settled, and who did not know the meaning of *Megalodon triqueter*, Wulf. Every one must confess, that hardly anything was left to be done

in the way of tracing out Wulfen's and other author's names, as to their real significations. But suddenly a new *southern breeze* arises and seems to overturn all which had been rebuilt with great pains. I do not think it is strong enough to surmount the Alps and reach safely to the North! It will probably meet a strong current from the opposite direction. In mercantile matters the name of an old firm has a great value, and is retained, if possible, for many generations, simply on account of its being known and universally accepted. There is nothing, which we can see, different in the case of the Dachstein-bivalve. The question with regard to the Geological position of *Megalodon triqueter* will be found more fully discussed in our conclusion.

Section 3.—*Lias. Tagling-limestone.*

Above the triassic beds follows a thickness of limestones of about 2,000 feet. The lower strata of these limestones correspond partly with the well known "Kössner-schichten" of the European Alps, and the upper seem to represent the liassic limestones, known under the name "Hierlatz-schichten" of the same mountain-ranges. I shall mention my palæontological reasons why, for the present, it seems preferable to describe both these limestones under one series, and separate them merely as lower and upper beds. The name is principally intended for the upper beds, the equivalents of the Hierlatz strata, and I shall, in my next survey, endeavour to ascertain whether the distinction of the lower beds into a separate group will find any more support, than now indicated, or not.

a. Lower Tagling-limestone.—Lower Lias.

A dark brown or grey, sandy or earthy, and mostly fine oolitic limestone is the principal rock of this series. It sometimes consists chiefly of fragments of shells, and the name of shell-limestone could be justly given to such strata. Beds of compact blueish limestone are rarer, but oftener they are earthy, and break into small angular fragments, like the dolomites of the Alps. It is not difficult to distinguish even pieces of this limestone from similar rocks of the triassic beds; the latter weathers out on the surface generally blueish-white or black, the former rusty, light brown, and the sandy elements are recognized at the first glance.

Stratigraphically this series is an exceedingly well marked one. Beginning again in our Bhabeh section from Muth, a large thickness of what I believe to be this limestone can be traced towards the tops of the hills on both sides of the Pin river. While the triassic limestones are very much disturbed and contorted, the lower Tagling limestone rests on these nearly horizontally, or is at least hardly affected by those disturbances. From a place,

a few miles East of Kuling, where the lower Tagling limestone comes down in a deep ravine, and where numbers of *Nerineæ* can be observed in it, I do not think that I am much mistaken in the explanation of the previous portion of the section, although we have never been able to ascend any of the higher ridges in the Pin valley.

Along the whole extent of the Spiti-shales, which will be described next, the lower Tagling limestone can be seen everywhere, and (with the exception of one locality South of Gieumal,) immediately below the shales, so that the upper Tagling limestone is wanting here altogether. At several localities round the villages Gieumal, Longja, Tshissigaong, Kibber and Chikkim the lower Tagling limestone contains the most characteristic fossils in immense quantities. The *Terebratula gregaria* and *Rhynchonella Austriaca* can be collected in thousands; *T. pyriformis*, *T. Schafhæutli*, *T. punctata* and *Rhyn. fissicostata* and others are somewhat less numerous, but still many specimens are to be had. With these Brachiopoda occur undoubtedly the Belemnites, and all the other fossils, which I describe from these beds. There is certainly no possible mixture with the fossils from any other strata excepting the fossils of the shales, and where this seems to have taken place, I shall mention the case.

The geographical extent of these limestones is very great. Inasmuch as these beds are the highest in all Southern and South-western parts of Spiti, they are more exposed on the surface than the preceding older rocks. Their extent to North-west and South-east is probably greater than that in Spiti, but has not as yet been determined.

FOSSILS OF THE LOWER TAGLING LIMESTONE.

The following is a review of the fossils from these beds.

I. *Brachiopoda*—10 species; all identical with European liassic forms, and most of them occurring in the beds known as *Strata of Kössen*, or *Avicula-contorta beds:—Terebratula gregaria*, *Rhynchonella Austriaca*, etc.

II. *Pelecypoda*—about 14 species; some of them as *Pecten Valoniensis*, *Avicula inæquivalvis*, and others are very characteristic.

III. *Gastropoda*—several species, but none of particular interest.

IV. *Cephalopoda*—two species of Ammonites, one of which is most probably *A. Germanii*, and three new species of Belemnites.

I. *Brachiopoda.*

1. TEREBRATULA GREGARIA, *Suess.*

1864. Deslongchamps in Pal. Franç. Terr. Jur. Brachiopoda, p. 64, with references to other authors. The species occurs in very great number, and we possess hundreds of specimens in all stages of growth, and of manifold variations. These are exactly similar to those which are known as *T. globata* or *perovalis*, Sow. The *Ter. Paueri* of Winkler is no doubt only a young *T. gregaria*, of which Schafhœutl in his Süd-Bayern. Lethæa geognostica (pl. LXX., figs. 2 and 3) gave a few representations. This species is especially common in the upper beds of the *Lower Tagling limestone*, immediately below the Spiti shales, in the neighbourhood of Gieumal, Longja, Kibber, Chikkim, &c.

It occurs in the *Kössner-schichten* of the Alps, in the lower Lias of France, &c. I have no doubt that Professor Salter's specimen figured (Strach. Pal. p. 100, pl. 21, fig. 6) under the name of *T. globata* belongs to this species; indeed it is not very easy to find out very characteristic differences between the liassic and oolitic fossil.

2. TEREBRATULA PYRIFORMIS, *Suess.*

1864. Deslongchamps in Pal. Franç. Terr. Jur. Brachiop. p. 70, with other references. Several very characteristic specimens of this species have been found with *T. gregaria* at Gieumal; and at Tshissigaong the species is less common, and often not so wide as those occurring in the "Kössner-schichten." Deslongchamps quotes it from the *lower lias* of Langres (Haute-Marne), where it ought to occur with *Gryphæa arcuata.*

3. TEREBRATULA PUNCTATA, *Sow.*

1864. Deslongchamps in Pal. Franç. Terr. Jur. Brachiop. p. 160, with other references. Only two specimens have been found with the previous species at Gieumal; they are in every respect perfectly iden-

tical with similar specimens, which the Survey collection possesses from the Marlstone of Clandown near Radstock. The length of the loop is exactly the same as figured by Davidson from Sowerby's original specimen, and distinguishes the species from *T. carnea* or *ornithocephala*. The punctuation is as well seen in one of our specimens. I cannot believe that M. Deslongchamps is quite correct in referring Oppel's *T. sinemuriensis* to this species, and shall state the reasons farther on, (p. 80). The specimen figured by Prof. Salter in Strachey's Palæont. pl. 21, fig. 5, and described (p. 99) under the name *T. carinata*, Lam., belongs probably to this species, and I am not certain whether even fig. 4 (ibid.) does not represent a depressed variety of the same species.

Ter. punctata is usually quoted from the middle Lias, but Deslongchamps (loc. cit. p. 164) allows it to go as far as the upper beds of the lower Lias, and I do not see any reason why it ought not to be found in the lower beds as well. The specimens figured by Quenstedt (Jura. pl. 9, figs. 1-3) (from Lias α) seem to exhibit very little difference.

4. TEREBRATULA (WALDHEIMIA) SCHAFHÆUTLI, *Stoppani*.

1857. Stud. Geol. p. 109. Numerous specimens have been found with the other Terebratulæ at Gieumal, and they are undoubtedly identical with the Austrian specimens from Hirtenberg.

The species has been described at first by Prof. Suess (1854. Denksch. d. k. Akad. Wien, Vol. VII., pt. II., p. 38) under the name of *T. cornuta*, Sow. Prof. Suess had compared at that time a very large series of *T. cornuta* with the Kössen Terebratula, and had arrived at the conclusion that both are the same species. I really do not know whether any body, after having compared again such a series, would not come to the very same conclusion! I must say, for my own part, that I am unable to fix any certain differences between the lower liassic species of the Himalayas and the true English *Ter. cornuta*. The only more remarkable difference is, that the lower-liassic (Kössen) specimens are nearly always somewhat slender towards the beak, and that the beak itself is more prominent. There are, however, very similar forms to be found under the middle-liassic *T. cornuta*. Prof. Suess seems to have himself given up the identity of the Kössner with Sowerby's species, as he proposed the name *Waldh. norica* for it. (*Vide* Sitzungsb. d. k. k. Geol. Reichsanstalt, vol. X., p. 46.)

The name quoted above *T. Schafhæutli*, Stopp. is that which is now usually accepted for the species by Alpine Geologists.

5. RHYNCHONELLA OBTUSIFRONS, *Suess.*

1854. Denksch. k. Akad. Wien, Vol. VII., pt. II, p. 55, pl. IV., fig 12. The Himalayan specimens are generally much larger than those from the Kössner-schichten, of which I have compared 12 specimens, but in all other respects they are perfectly identical. Prof. Suess (loc. cit. p. 56.) remarks, that larger specimens of the same species have been found plentifully in the Hierlatz-schichten (of the middle Lias), and that they show a great amount of variation. Probably it has been, from the latter strata, described by Professor Oppel under the name of *Rhyn. Emmerichi*, (Zeitsch. d. Deutsch. Geol. Gesellsch. vol. XIII., p. 542, pl. XII., fig. 1.)

Our specimens vary in their thickness; some of them being quite as much depressed as the specimens from Enzesfeld near Vienna, others are more inflated, and the fold and sinus are more strongly expressed. The usual number of the plications on the fold is three, and two corresponding ones on the sinus; rarely there are only two plicæ on the fold, but sometimes four are to be met with.

There can be no doubt that the species occurs in the German Lias; but the great number of different forms, which usually go under the universal name of *Ter. triplicata*, require a thorough revision.

6. RHYNCHONELLA PEDATA, *Bronn*, sp.

1854. Suess in Denksch. Akad. Wien, Vol. VII., pt. II., p 61. A few specimens have been found in the uppermost beds of the Tagling limestone; although common in the sandy limestone itself, it is very difficult to obtain even one perfect specimen. I have not been able to compare any actual European specimens with our fossils, but they agree so well with Suess' figure, that there can be hardly any doubt as to their true identity. Mr. Gümbel, in his "Geognostische Beschreibung des bayerischen Alpen gebirges", 1861, refers this species to his "lower Alpine Keuper"—triassic beds equivalent to our Lilang series.

7. RHYNCHONELLA FISSICOSTATA, *Suess.*

1854. Denksch. Akad. Wien, VII., pt. II., p. 58. This is a very characteristic species of the Kössen strata, and is not uncommon South

of Gieumal; a few specimens have been met with in the same strata below the shales North-east of Kaja and near Tshissigaong. Some of the smaller specimens from Gieumal can be well attributed to the *R. fissicostata*, var. *applanata* of Gümbel, (Bay. Alpen-gebirge, p. 401), they are lenticular, very flat, and the sinus scarcely marked at all.

8. RHYNCHONELLA AUTSRIACA, *Suess.*

1854. Denksch. Akad. Wien, VII., pt. II., p. 53. All our specimens agree perfectly with the smaller and thinner ribbed variety, which Professor Suess mentions from Bernreuth, one specimen from which locality we have compared with ours. Among several hundreds of specimens we do not possess a single one of the inflated and more coarsely ribbed variety, which is figured by Professor Suess, and which is identical with Quenstedt's figs. 13-14. (pl. 22, 'Jura') of *T. Austriaca.* Specimens quite similar to this latter variety have been, however, collected by my friend Mr. Mallet in 1860 somewhere near the Niti pass; their exact stratigraphical position is not known.

9. RHYNCHONELLA VARIABILIS, *Schloth.*

1852. Davidson, Brit. Brach. pt. III., p. 78.—1854, Suess in Denksch. Akad. Wien, VII., pt. II., p. 56. Of this species only one specimen has been found South of Gieumal, but several have been met with in the same beds in Rupshu; they agree fully with compared specimens from the marlstone near Radstock, and undergo the same variations as regards the number of plicæ on the fold and sinus.

Prof. Salter mentions the species from Col. Strachey's collections from the neighbourhood of Niti. (*Vide* Strachey's Palæontology, p. 101.)

10. RHYNCHONELLA RINGENS, *Herault, sp.*

1852. Davids. Brit. Brach. pt. III. pl. 74. Our specimens from the South of Gieumal in general agree well with L. von Buch's and Davidson's figures and descriptions.

The principal variation exists only in the number of costæ on the sinus, there being from one to three of these and correspondingly from 2 to 4 on the mesial fold; the usual number in the sinus is only two, as in most of the British or French specimens, somewhat more rarely there is only one and very seldom there are three in the sinus. Our specimens have real costæ in the sinus better expressed than in the European, but there is no other difference in form

or ornamentation of the shell. The species is quoted by D'Orbigny from the upper Lias; Mr. Davidson (loc. cit. p. 75) is inclined to believe that it occurs in the lower oolite, from which it is quoted also by Morris (Cat. p. 149). Professor Oppel says (Jura, p. 432) that it probably occurs at the base of the lower oolite. The species has, I believe, not been noticed as yet from Germany.

It is well worth while to draw attention to Rouillier's *Terebratula bidens* (Phill.), var. *primaria, secundaria* and *tertiaria*, in the Bull. Soc. de Moscou 1848, pl. F., figs. 4-7, and T. *triplicata* (Phill.) *typica*, ibidem fig. 8. All these figures agree very well with our specimen, and as regards the costæ in the sinus even better than those previously quoted.

II.—Pelecypoda.

1. OSTREA, *conf.* O. ACUMINATA, Sowerby.

Ostrea acuminata, Sow. Salter in Strachey's Palæont. p. 91, pl. 22, fig. 3. The Himalayan specimens are so much like the common oolitic fossil, that there seems little chance indeed to separate them. What I can perceive as a little difference is, that the muscular impression lies at about half of the height of the shell in the oolitic *O. acuminata*, and that it is rather rounded (*vide* Chapuis, Foss d. Luxemburg 1853. pl. XXXII, fig. 6), while in our fossil the impression is more elongated and placed much closer to the apex.

This small oyster is a very characteristic fossil of the Lower Tagling limestone, and occurs, associated in great quantities in beds, exactly like *Ost. acuminata*. It is decidedly not from the Spiti shales, but occurs always below, in a quite different limestone, and with the characteristic Brachiopoda previously quoted.

2. OSTREA, *conf.* O. ANOMALA, Terq. (Mém. Soc. Geol. France, V. p. 25, fig. 4.)* One specimen, which is not unlike Terquem's figure of a lower liassic species, has been found with *T. gregaria* North-east of Kaja.

3. AMUSIUM *sp.*

It is, I believe, high time that we adopted some systematical arrangement as regards the universal denomination *Pecten*, otherwise the quota-

*N. B.—Great confusion exists here as to the references to the text and explanation of plates.

tion of quite different forms as being identical will have no end. The three genera, as fixed by Messrs. Adams, *Pecten*, *Vola*, and *Amusium*, will probably answer best for the pressing wants of the present. It will perhaps be necessary to accept more genera, but for that purpose a critical examination of all known Pectens is unavoidable. It is especially in the genus *Amusium* that a difference in colour and ornamentation of the two valves nearly always occurs, and, to characterize a new species, both the valves ought to be known, otherwise repetition in naming one and the same species can scarcely be avoided.

Our present species under consideration has been figured and noticed by Prof. Salter under the name of *Pecten lens*, (Strachey's Pal., p. 94, pl. 22, fig. 8), a species which is a true *Pecten* with unequal ears, and has nothing whatever to do with this *lower liassic species*. We have the true *Pecten lens* from the Spiti shales, and could only in this way account for some inexplicable mistake in figure and type. Our specimens are exactly like Prof. Salter's figure, only some of them are still a little narrower posteriorly.

As I have no materials whatever to compare with, and as a number of similar species have been described already by Quenstedt, Zieten, etc., and lately numbers of new species have been named by Gümbel from the same strata, I rather prefer not to name the species.

I would especially suggest the comparison of *P. sepultus*, Quenst. (Jura, p. 48, pl. 4, fig. 11) and *Pecten glaber*, Zieten, (pl. 53; fig. 1). According to the account given by Quenstedt of *Pect. glaber* there seems to exist a great deal of confounding of different forms under one name. Common near Gieumal and North of Kibber.

4. PECTEN, *conf.* P. PALOSUS, *Stol.*

1861. Sitzungsb. Akad. Wien, Vol. 43, p, 197, pl. 6, fig. 8.

One specimen from the South of Gieumal seems to be quite identical with the species which I have described from the Alpine "Hierlatz-schichten." The radiating ribs are somewhat closer on our specimen; this may be, however, expected on the preserved shell; my Alpine specimens were chiefly casts.

5. PECTEN MONILIFER and P. SABAL, *Salter*, in Strachey's Palæont. pp. 93 and 94, pl. 22, figs. 10 and 11. We possess only one specimen of the right valve; a complete cast. The ears are small and

unequal. The ribbing consists of 6 stronger radiating and tuberculated ribs (*P. monilifer*), and each of these has another smooth secondary rib on either side (*P. sabal*). It is therefore just as correct to attribute our specimen to either of the two species, which I would rather believe are not specifically different. As Salter's examination rests only upon fragments, the question about their identity must be postponed until better materials have been obtained. It is of no use to name fragments even when 'from eternal snows'! I must also remark, that it does not seem to me quite certain, whether the species comes from the lower Tagling beds, and whether it is not rather a triassic one, allied to *P. moniliferus*, Bronn (in Münster's Beiträge 1841. p. 72, pl. VII, fig. 4) from the St Cassian strata. Our specimen was brought by Mr. Theobald in 1861 from Mikkim in the Pin-valley. I have passed over the same locality, but not met with any more specimens. There are, except carboniferous, only triassic rocks down at the river, and the matrix of the specimen is indeed somewhat like to some beds of the light-coloured triassic limestone. Lower Tagling limestone occurs, however, plentifully above the Trias, a few hundred feet higher, so that the specimen may come just as well from a block of this limestone.

6. PECTEN BIFRONS, *Salter*.

1865. in Strachey's Palæont., p. 92, pl. 22, figs. 5-7, *in parte*. There is no doubt very great confusion as regards this species, and we could only wish a revision of the materials collected by Col. Strachey. Surely, they must come from different strata!

I cannot attempt now to fix the species, as our own materials are not sufficient; a few remarks, however, may be found useful. Fig. 5 of Prof. Salter's *P. bifrons* represents undoubtedly a species from the upper jurassic (*Gieumal sandstone*). I have collected myself this species above Gieumal in the calcareous beds of this sandstone. Fig. 6 is doubtful, but probably the same species as represented in Fig. 7. This is a species quite different from the jurassic one; it is a more rounded shell, apparently more convex, and has smaller ears; the biplicate ribs are much better expressed. This latter form is from the lower liassic beds; and there is still a third biplicate species from the same beds, which is quite as oblique as a Lima.

7. PECTEN VALONIENSIS, *Defr.*

1856, Oppel and Suess in Sitzungsb. Akad. Wien, Vol. XXI., p. 548, pl. II., fig. 8.

1861. Moore in Quart. Jour. Geol. Soc. Lond., Vol. XVII., pl. 16, fig. 6.

Several specimens have been found South of Gieumal with the characteristic Brachiopoda of the "Kössen" strata. They are exactly like the European fossil and cannot be mistaken, although usually only of small size. Possibly Mr. Salter's fig. 12 on pl. 22 in Strachey's Palæontology may represent a specimen of this species. Mr. Salter remarks, that it occurs with the liassic *Cardium truncatum*, Sow.

There have been lately from the same strata in Europe so many new and allied species established, that it would be no wonder to see the *Pecten Valoniensis* meet with the same fate as many other old known species. When we cannot get out of the confusion, which we ourselves have induced, we then propose to abolish these old names, as has been attempted with *Lima gigantea*, *Am. biplex*, and many others.

8. LIMA DENSICOSTA, *Quenst.*

1861. Sitzungsb. Akad. Wien, Vol. 43, p. 199, pl. VII., fig. 3.

The Himalayan form, found in the lower Tagling limestone, South of Gieumal, agrees even better with Quenstedt's fig. 24, pl. 18 (in his 'Jura') than with that which I have described from the Hierlatz-schichten of the Alps. It is quite as oblique and narrow as Quenstedt's original figure.

In the paper quoted above I have referred to several similar species, and it seems to me now more probable, than before, that many of these liassic little Limas with simple ribs are not specifically different. It is not to be expected, that we have in every zone of one formation altogether a different fauna. Neither the conditions nor the species could make such rapid progress in their changes.

9. AVICULA INÆQUIVALVIS, *Sow.*

1861. Sitzungsb. Akad. Wien, Vol. 43, p. 198. The true European species, with unequal intermediate ribs, occurs in the lower Tagling limestone near Gieumal and South of the Parang-pass with *T. gregaria*, *Rhynch. fissicostata*, etc. It is now generally admitted that the

liassic species is not different from the jurassic, but we cannot possibly allow the variation so far as to regard Prof. Salter's representation of *A. inæquivalvis*, in Strachey's Palæont. p. 91, pl. 22, fig. 13, as the same, if the figure be really correct, as it appears to be. I would rather say Prof. Salter's figure represents a specimen of *A. echinata*, Sow.: it would, however, be a somewhat more coarsely ribbed variety, such as do occur, though not usually, in the Gieumal sandstone.

10. AVICULA PUNCTATA, *Stol.* Pl. VI., fig. 2.

A. testa oblique ovata, inæquilaterali, parum convexa; aurieulis inæqualibus; auriculo antico majore, sinuato; superficie lineis radiantibus, ad peripheriam curvatis ornata, interstitiis punctatis.

A very slightly convex valve, very oblique, approaching in form to a parallelogram. The shell is thin, nacreous, as usually in the genus *Avicula*, and the surface is ornamented with numerous, towards the periphery slightly curved, elevated lines, the intermediate grooves being finely punctated. The ears are equal, the anterior one much longer, slightly sinuated at the end, with flexuous lines of growth, and with a deep sinus on its basis.

Locality. The species has been met North of the Manirang pass and South of Gieumal.

11. GERVILLIA, *sp.*

Only very imperfect specimens have been found South of Gieumal, resembling very much the *G. olifex* of Quenstedt, (Jura, p. 86, pl. XI., fig. 4) from Lias *α*.

12. ARCA, *sp.* (Macrodon).

A single specimen from the South of the Parang pass, (below the camping ground Bhaonrhochan,) does not shew any difference from *Arca Lycetti*, Moore, (Quart. Jour. Geol. Soc. Lond., 1861, pl. XVI., fig. 7) from the Rhætic (*Avicula contorta*) beds.

III.—Gastropoda.

1. DENTALIUM, *sp.*, not unlike Prof. Phillip's figure of *D. giganteum* (Geol. Yorksh. pl. XIV. fig. 8) from the Marlstone series. South of the Parang pass.

2. NERITA, *sp. nov.*, from North of Kaja on the ascent towards Hikkim; quite a globular and smooth form, to which I do not know any European ally.

3. NATICA, *conf.* PELOPS, *D'Orb.* (Pal. univ. pl. 288, figs. 16-17, from the upper Lias). One specimen from North-east of Kaja, apparently undistinguishable from D'Orbigny's figure.

4. CHEMNITZIA, *conf.* CH. COARCTATA, *Desh.* (D'Orbigny, Pal. univ. p. 45, pl. 240, figs. 1-3) from the lower Oolite. Near Kibber several specimens were obtained (in the lower Tagling limestone) of a *Chemnitzia*, which is perfectly like the jurassic species, but it is impossible to pronounce identity, as none of our specimens is complete.

5. CHEMNITZIA, *sp.*

A few specimens of a little *Chemnitzia* have been found with *Rhyn. fissicostata* and *Ter. gregaria* North-east of Kaja, below the Spiti shales; they recal very much D'Orbigny's *Ch. Phidias* from the lower lias, (Pal. univ. II., p. 34, pl. 237, fig. 12), only the angle of the spire is a very little larger in the French species.

6. NERINEA, *sp.*

North-east of Kaja *Nerineæ* occur very plentifully in the lower Tagling limestone with *T. gregaria.* They are in general like those which I have to mention from the upper beds, and which in form resemble *N. Goodhalii*, Sow., but I have never observed them, neither here nor South of Gieumal, of that large size, being usually thin and often with an obtuse vertex.

I met also with several *Nerineæ* in the Pin valley, a few miles West of the mouth of the Pin river. As I am, however, well aware of the difficulties which exist in the determination of this genus, and how variable even the folds* are—generally believed to be the best character of a *Nerinea*—I shall not endeavour to establish new species until really good materials have been provided.

IV.—Cephalopoda.

1. AMMONITES, *conf.* GERMANII, *D'Orb.*

Pal. Franç. Terr. Jur. I., p. 520, pl. 101. A single specimen, which we possess from the North of the Manirang pass, and which is a cast only, agrees well with D'Orbigny's figures and descriptions. The number

* It is, I believe, known, that they usually become weaker and often disappear altogether near the mouth; sometimes one or the other fold disappears at half the height of the spire, others become stronger.

of transverse sulci is 6 in our specimen: *Am. interruptus*, (Zieten's Petref. Würtembg., p. 25, pl. XV., fig. 3.) which is identical with D'Orbigny's *Am. Germanii*, has 7 transverse sulci, and in D'Orbigny's figures the number varies from 8 to 10. This seems to be, therefore, a point of great variation. There is no other objection whatever to identify our specimen with *Am. Germanii*.

2. AMMONITES, *conf.* MACROCEPHALUS, *Schlotheim.*

Two specimens, both not very well preserved, were brought by Messrs. Theobald and Mallet in 1861 from the North of the Manirang pass in Spiti. Except a finer ribbing they do not seem to differ from the *Am. macrocephalus* in the Spiti shales. I found, besides, several undistinguishable fragments and a little perfect specimen in the Para valley of Rupshu (together with *Terebratula gregaria, Rhynchonella variabilis* and *Austriaca*, and others,) and cannot give at present any positive characters to distinguish it from the jurassic species. Form of the shell, ribs and sutures seem to be quite similar, but the striation is always finer.

3. BELEMNITES BUDHAICUS, *Stol.* Pl. VI., figs. 3-6.

Guard cylindrical, very slightly tapering towards the end, smooth, without any vascular impressions visible; in front with a deep furrow, which extends from about the middle of the guard to its lower termination; the section is usually circular.

The species must have attained a great length, as no trace of the alveole is to be seen on any of our specimens (fig. 4 being the largest). They are very often, and at different localities, found with a number of transverse breaks, which are no doubt accidental, but they have the appearance of some kind of joints.

Localities: South of Gieumal, near Tshissigaong and West of Chikkim; found loose in the beds below the Spiti shales.

4. BELEMNITES BISULCATUS, *Stol.* Pl. VIII., figs. 1-4.

The guard is smooth, with two furrows; one in front and one opposite to it, the latter being narrower and shorter, and not extending up to the lower termination, while the former terminates near the point broadly, but shallow. The dorsal groove is sometimes much shorter than the ventral. The section is, on the upper portion of the guard, where both the furrows exist, oval with the longer diameter in the line of

the furrows: towards the end, where the dorsal furrow gradually disappears, the section becomes oval in the opposite direction, the guard being somewhat compressed in the line of the furrows of this species; the guard resembles some species of the *Hastati*. No vascular impressions or any kind of secondary grooves near the point are visible.

The angle of the guard measures about 15°; both the sulci on it are narrow, and deeply cut in the surface of the shell.

Localities. Loose specimens have been found below the Spiti shales near Gieumal, Tshissigaong and West of Chikkim. South of Gieumal the species occurs plentifully in the hard Tagling limestone with *Terebratula gregaria, Rhynch. ringens, Austriaca, fissicostata,* and others. With the same fossils, I have observed it in Rupshu near Tatang-yogma in the Para valley; there can be, therefore, not the slightest doubt as regards this species being really from the same beds as the other lower liassic fossils.

5. BELEMNITES TIBETICUS, *Stol.* Pl. VIII., figs. 5-6.

A cylindrical guard resembling *Bel. digitalis.* The surface is quite smooth, and on some of the small specimens two fine and only very short grooves near the point are indicated, others have slight and simple vascular impressions on the sides. On larger specimens not anything of both is usually visible, but the guard has on its upper portion a slight groove in front, and the shell becomes at the same time somewhat slender. The section is nearly round, sometimes a little compressed laterally. Nothing of the alveole is seen on any of our specimens.

Localities: Round Gieumal very common in the limestone, and loose, below the Spiti shales. At Tshissigaong and Chikkim the species was found with the previous, and one specimen has been met with in the lower Tagling limestone, South of the Parang pass. The co-existence of this species with *T. gregaria, Rhynch. fissicostata* and *Austriaca,* &c., is, therefore, certain; it seems, however, to occur in the upper beds also. The only allied species which I can find among European Belemnites is a species from the Lias at Gammelshausen in Würtemburg, noticed and figured by Zieten (p. 29, pl. 22, fig. 4) as *Bel. semihastatus.* It would be worth while to compare these two forms.

Section 4. (b) Upper Tagling limestone.—Middle Lias.

This is a dark blue earthy or dolomitic limestone, which occupies the top of the portion of the Baralatse range North of Spiti. In its mineralogical characters it resembles some of the Alpine limestones of exactly the same age, as for instance those on the 'Gratzalpe' near Aussee, in Upper Austria. (*Vide* Sitzungsb. d. k. Akad. Wien, 1861. Vol. XLIII. p. 157). It requires careful attention to distinguish it in pieces from the Para limestone or the beds with *Megalodon triqueter.* I do not know anything about the further geographical extension of this limestone, but its superposition on the *lower Tagling limestone* on the Parang and Tagling passes is an undoubted fact.

On the Parang pass I collected several Gastropoda in this limestone, identical in species with those from the Alpine "Hierlatz-schichten," of which I wrote a Monograph quoted above. I mention here as the more common forms *Chemnitzia undulata* and *Trochus epulus,* as being the best known fossils. Fragments of Belemnites occurred with these Gastropoda, of which latter none has been observed in the lower limestone. On the Tagling pass I noticed, however, in this upper limestone a *Nerinea,* apparently not different from that of the lower beds, and also the *Belemnites bisulcatus* (?) or at least a species very like it. On account of the limited extent, to which the upper limestone is as yet known, and of its palæontological relations, I think it better for the present not to define it quite strictly, although I rather believe that it may be possibly separated, so soon as the country has been more thoroughly examined and more fossils have been collected. The partial difference of the mineralogical characters, and the superposition, are no doubt strongly in favour of this opinion.

FOSSILS.

I. *Brachiopoda.*

1. TEREBRATULA SINEMURIENSIS, *Oppel,* (Zeitsch. d. Deutsch. Geol. Gesellsch. XIII., p. 534, pl. X., fig. 2). Prof. Oppel described

the species from the lower Lias: it seems to be justly separated from *T. numismalis*, or *punctata*, Sow. With the latter it has been lately united by M. Deslongchamps, (Pal. Franç. Brach. 1864, p. 160). Our specimens, five in number, have been collected South of the Parang pass; no other fossils have been met with, and I do not wish to express full confidence in my placing the species in the upper beds of the Tagling limestone, as the strata might possibly belong to the lower series, although the limestone itself agrees much better with the upper beds. I believe this species differs from similar specimens of *T. punctata* by a longer and less incurved beak, larger deltidial plates, much finer septum, narrower and shorter adductor-impressions. Besides *T. punctata* is nearly always posteriorly obtuse; *T. sinemuriensis*, so far as visible on Oppel's figures and on our specimens, is equally rounded or even somewhat prolonged.

It is hardly necessary that we should trespass on our space by giving a new figure of the Himalayan form; the five specimens, which we possess, vary only a little in their width, but are otherwise exactly like Prof. Oppel's figure.

II. *Pelecypoda.*

MODIOLA, *sp.* resembling the oolitic *Mytilus subreniformis*, M. & Lyc. (Great Ool. Foss. pt. II, p. 39, pl. IV., fig. II). A single specimen, which is imperfect and appears to be from the upper beds. It was found near the Parang pass.

III. *Gastropoda.*

1. NERITOPSIS, *conf*, N. ELEGANTISSIMA, *Hörnes*, Sitzungsb. Akad. Wien, Vol. 43, p. 179, pl. 3, fig. 7—from the middle liassic strata of the Alps, the Hierlatz-schichten. Several very like and most probably identical specimens have been met with on the top of the Parang pass.

2. CHEMNITZIA UNDULATA, *Reuss*, (*Stoliczka*, in Sitzungsb. d. k. Akad. vol. 43, p. 163, pl. 1, fig. 1). Specimens obtained on the top of the Parang pass are perfectly identical with those described by myself from the *Hierlatz-strata* of the Austrian Alps.

3. TROCHUS LATILABRUS, *Stol.* (ibidem, p. 173, pl. 2, fig. 9,) from the Parang pass, undoubtedly identical with the Alpine liassic species.

4. TROCHUS EPULUS, *D'Orb.* (Stoliczka, ibid. p. 167, pl. 1, fig. 11.) from the Parang pass; it is a common liassic fossil in the Alps and in North France.

5. TROCHUS ATTENUATUS, *Stol.* (Ibid. p. 171, pl. II., fig. 1). A few specimens from the Parang pass seem to belong to this species, but they are too badly preserved to be determined with required certainty. I believe the species, which Mr. Etheridge (Quar. Jour. Geol. Soc. Lond., Vol. XX., p. 388) quotes as *Cerithium*? like *C. muricatum*, Sow. sp. from Captain Godwin Austen's collection of Himalayan fossils, is the same as ours. It is no doubt from the same beds, only farther to North-west than our locality.

6. ENCYCLUS, *sp.* from the top of the Parang pass. The single specimen is too imperfect for description.

7. ACTEONINA, *conf.* CINCTA, *Goldf. sp.* Petref. Germ. III., p. 48, pl. 177, fig. 9. D'Orb. Prodrome I., p. 247.

One specimen from the Parang pass agrees pretty well with Goldfuss's figure, which represents a specimen from the liassic strata at Banz. It is only a cast, with cylindrical whorls on which the spiral furrows are very well marked. It may be an *Acteonina*, which generic name D'Orbigny proposed instead of Goldfuss's original name *Tornatella*. The spire has no folds whatever, but this point is not mentioned at all by Goldfuss.

The specimen has been found on the Parang pass by Mr. W. Theobald, and I believe from the matrix that it belongs to the upper series of the Tagling limestone.

8. NERINEA, *conf.* GOODHALLII, *Sow.* Trans. Geol. Soc. Lond. IV., pl. 23, fig. 12.

In referring to a similarity of the Himalayan specimens with the English fossil from the Calcareous Grit, we do not wish to express more than what is externally seen on imperfect specimens. I have no doubt* that *Mr. Etheridge* (Quart. Jour. Geol. Soc. London, Vol. XX., p. 388) means the same species, which he says is allied to *N. Goodhallii*. The specimens, which I obtained on the Parang and farther to North-west on the Tagling pass, differ from the English *Nerinea* by a greater number of internal folds. Our specimens have three folds

* From Capt. Godwin Austen's personal communication.

on the spire, one on the upper lip and two on the outer lip. Of the last two the lower is by much stronger than any of the others. The concave and smooth whorls are apparently quite like to those of *N. Goodhallii.*

IV. Cephalopoda.

BELEMNITES *sp.* On the top of the Parang, as well as on the Tagling pass, I have noticed fragments of Belemnites in the limestone with the other Gastropoda. From their much elongated form I believed them on the spot to be identical with *Bel. bisulcatus* (nov. sp.), although I am unable at present to ascertain it fully.

AMMONITES *sp.* (conf. MACROCEPHALUS, *Schloth.*) Mr. Theobald has brought from the North of the Manirang pass (?) specimens, and I found myself another small specimen in Rupshu in beds with *Tereb. gregaria,* etc. It is really difficult to pronounce any thing quite certain about this species, as all the specimens are not well preserved. They differ from compressed varieties of *Am. macrocephalus* merely in the finer striation.

Section 5. Jurassic—Clayey Slates.

In the Section Nos. 2 and 3 on Plate II, I have noted a small thickness of beds South of Gieumal, between the Tagling limestone and the Spiti shales. At this locality the position of the slates is unquestionable, between the Tagling limestone and the Spiti shales. Their mineralogical characters are different from those of the rocks above and below.

The beds consist of thin layers of clayey black or brown slates, which contain a very great quantity of little fragments of different *Mollusca,* as if they had been formed only from the aggregated debris of shells. In fact, these beds, the whole thickness of which does not

exceed 50 feet, seem to be quite a local deposit; I have not observed them at any other locality in Spiti; although I have examined the superposition of the Spiti shales and the Tagling limestone at more than one place.

Of fossils I could recognize only fragments of *Belemnites*, which do not admit of a specific determination, and a *Posidonomya*, which I am unable to distinguish from *P. ornati*, Quenst. Some of our specimens are well preserved, and they agree perfectly with Quenstedt's figure in his Petrefactenk. pl. 42, fig. 16. Figure 27, as given on plate 67 in the "Jura," does not seem to be so characteristic. *Pos. ornati* occurs with *Am. ornatus* in the German Jura, and Oppel (Jura, p. 567) says that he found it in England in beds above the *Am. macrocephalus*. This last-named species does not occur in Spiti at the same locality, but a little above these slates, although in the lowest beds of the Spiti shales.

I have often thought whether these slates ought not in some way to represent the Upper Tagling limestone, which, on the top of the Parang pass, contains liassic Gastropoda; but the Posidonomya is certainly not identical with *Pos. Bronni;* it could, if this supposition were to receive any farther support, be only a new species. I have quoted this small thickness of beds separately, merely because they are really lithologically different from the others, and, should any thing be done in the way of working out different beds in the jurassic deposits of the Himalaya, these slates may then receive more attention.

Section 6. Spiti Shales.—Oolitic.

Not one of the other formations is lithologically so remarkably and easily distinguished as the Spiti shales, from which beds most of the Spiti Ammonites have been long known since Dr. Gerard's first discoveries.

In the middle portion of the valley, and from 2,000 to 3,000 feet above the left bank of the Spiti river, there extends (from North-west to South-east) a longitudinal ellipse of these rocks. The length of this ellipse is about 20 miles only, and the greatest width never exceeds 5 miles; being in the southern part generally only 3 miles or even less. The geographical extent of the ellipse is marked by a great number of villages, of which Gieumal is the most southern and Chikkim the most northern; these two villages lie near the extremities of the ellipse.

The rock itself is a black, crumbling shale, breaking into little angular fragments when dry, and easily decomposing to a black soil when wet. Calcareous concretions occur more or less numerously throughout the series, and contain often, as a nucleus, an Ammonite, a Belemnite, or some other fossil.

These shales overlie the 'Lower Tagling limestone' *conformably*, and dip everywhere towards the centre of the ellipse. It is, however, generally very difficult to observe any regular stratification in them, resulting from their crumbling and easily fractured nature and easy decomposition. A stream runs generally on the boundary between the two formations. The thickness of the shales is usually only 2 or 300 feet; and hardly ever exceeds 500 feet.

We have not observed them beyond the extent of the said ellipse, neither in Rupshu nor in Spiti itself, and accordingly all the still younger formations do not extend beyond the limit of the shales.

A great number and variety of fossils are known already from these rocks through the researches and labors of others, but there is still much to be done. I have attempted to give a revised catalogue

with notes on all the species, which are known in Spiti from these beds, and have excluded others, which belong to other formations. I need hardly say anything more here, than I have already stated speaking of the triassic fossils. Every attention has been given to avoid any confusion with fossils from other beds.

With regard to my views, expressed in the palæontological notes themselves, and relating to different species, I have been guided not only by my previous studies and some little experience, but by a comparison of actual European specimens as well. Should my opinions appear doubtful or even perhaps exaggerated as to one point or the other, I am gladly responsible for them; without pretending that they are absolutely correct. But they are derived, I know, from good materials and not through any careless work. I shall be just as glad to give them up as soon as they are proved to be incorrect by any future discoveries. Neither a small nor a great number of species can satisfy the palæontologist or the geologist, if he is always in doubt about their determination; but descriptions of *specimens* from different localities *as species* is mischievous.

FOSSILS OF THE SPITI SHALES.

The following is a list of all fossils known from the Spiti shales.

Echinodermata (?)—Mr. Blanford notes a *Salenia* from Spiti (Journ. As. Soc. Bengal, 1863, p. 137, pl. II. fig. 9); the original is very defective, and even the genus doubtful. The locality of the specimen is unknown.

I.—*Brachiopoda*; two species, one of which is the common oolitic *Rhyn. varians*, Schloth.

II.—*Pelecypoda*, 17 species; *Pecten lens*, *Nucula cuneiformis*, *Astarte major* and *unilateralis*, *Trigonia costata* and some species of the genus *Ancella* are the most characteristic.

III.—*Gastropoda*, only two species of Pleurotomaria as yet known.

IV.—*Cephalopoda*, 19 species, of which the best known European forms are, *Am. macrocephalus*, *Parkinsoni*, *curvicosta* (Opp.), *triplicatus* and *biplex*, and *Belemnites canaliculatus*. They are all oolitic species.

I.—*Brachiopoda.*

1. TEREBRATULA, *sp.* A single fragment has been met with North of Kibber near the camping ground *Tangtag*; the specimen may belong to *T. simplex*, or *ovoides*.

2. RHYNCHONELLA VARIANS, *Schloth, sp.* (1852. Davidson, Brit. Brach. p. 83, pl. 17, figs. 15-16). The species is not common in the Spiti shales; I met with only two specimens at Gieumal and one at Kibber. The specimens are undoubtedly identical with the jurassic species of Europe, and agree especially well with the inferior oolite specimens from Whatley.

II.—*Pelecypoda.*

1. OSTREA, *sp.* The Himalayan species from the Spiti shales, is no doubt allied to *Ost. flabelloides, Lam.* (Desh.), with which species Prof. Salter unites it (Strachey's Palæont. p. 90, pl. 22, fig. 1). But in *Ostrea flabelloides* and *Marshii*, both of which are perhaps identical, the ribs and furrows are sharp and angular; in our species the ribs are sharp, although not nearly so much elevated, but the furrows are much broader and roundish hollowed out. There are, however, so many similar variations known that we think it more advisable to defer the question of identity with one or the other species until we may procure better specimens; the present materials being very imperfect. The Cutch *O. Marshii* is more likely to agree with *Ost. flabelloides* in the form of its ribs and the placing of the muscular impression, which is only somewhat more elongated.

PECTEN LENS, *Sow.* (Mor. and Lyc. Great Ool. Foss. pt. II, p. 11, pl. II., fig. 1: *non idem* Salter, in Strachey's Palæont. pl. 22, fig. 8). The true oolitic species occurs in the Spiti shales, and is not to be mistaken, even in fragments, for the lower liassic *Avicula punctata, n. sp.* (p. 76). I rather believe that the species, which is figured by Mr. Salter (loc. cit. pl. 22, fig. 9) under the name of *Pecten comatus*, Münst., belongs to *P. lens*, and that some mistake must have occurred in figuring the specimens.

3. AMUSIUM, *sp. conf.* PECTEN SOLIDUS, Trautsch. 1861. Bull. Soc. Mosc. p. 76, pl. VI., fig. 4. Our Himalayan species was found North of Kibber in the Spiti shales. It agrees exactly with *Trautschold's*

figure, and possesses similarly a few distant concentric striæ, the interspaces between which are finely striated according to the lines of growth. *Trautschold* refers especially to the solid shell of the Russian species, while our specimen (only one having as yet been found) has apparently a very thin shell; but this could possibly be only the interior nacreous layer of the valve.

Already in 1806 *M. Roemer* described an oolitic species under the same name *P. solidus;* it is indeed not very unlike to that of Trautschold or the Himalayan form. *M. Roemer* remarks equally a considerable thickness of the shell.

4. ANCELLA BLANFORDIANA, *Stol.*

(*Monotis concentricus*, Blanford, 1863. Jour. As. Soc. Beng. p. 136, pl. IV., figs. 6-7: non *Ancella concentrica*, Keyserling, Petschoraland, p. 300). The genus Ancella is a very characteristic fossil for the eastern jurassic deposits, as mentioned often by Keyserling, Trautschold, Eichwald, and others. The present species is very like *Anc. Pallasii*, Keys., only the anterior portion of the valves is longer and more rounded. There are apparently no intermediate striæ in the sulci of the left or more convex valve. The characters of the thin shell are exactly the same in the Indian specimens, as they have been recorded by Keyserling, Trautschold and others.

The species is not common in the Spiti shales. The figure in Strachey's Palæont. (pl. 22., fig. 4) is not quite correct as to the form of the sinus of the right valve.

5. ANCELLA LEGUMINOSA, *Stol.* Pl. VIII., fig. 8.

Anc. testa inæquivalvis, valde inæquilateralis, oblique elongata, leguminosa; valva sinistra convexa, umbone maxime-incurvato; valva dextra subplana; superficies striis radiantibus atque concentricis, undulatis, ornata.

A very oblique, pod-like shell, on which the hinge is placed quite closely to the frontal termination. The right valve is slightly convex, with pointed umbo and a small sinus in front of it. The left valve is much more strongly convex, with an incurved beak and a corresponding elevation of the margin opposite the sinus of the right valve. Coarser and finer striæ of growth and radiating lines ornament the shell surface, they are both undulating.

Locality. Only the figured specimen has been found at Kibber.

6. LIMA, *sp.* from Kibber, very like the *L. rigida*, Desh.

There is in Dr. Gerard's collection a species of Lima with radiating ribs and numerous fine striæ between them; this would agree with what Prof. Oppel calls *L. Roberti* (Pal. Mitth. 1864, p. 273). I have not met the species myself in the Spiti shales, and as the rock of *Dr. Gerard's* specimen, which is not complete, is somewhat different, I prefer omitting here to quote it more particularly.

7. INOCERAMUS HOOKERI, *Salter*, 1865, in Strachey's Palæont. p. 98, pl. 23, fig. 1 is a true Inoceramus, so far as can be seen from the form of the shell and the dentitions of the hinge line. I have seen only casts as yet. It occurs not uncommonly in the Spiti shales at Ki and Gieumal.

8. MACRODON EGERTONIANUM, *Stol.* Pl. VIII. fig. 7.

(*Cucullæa virgata*, Blanford, in Journ. As. Soc. Beng. 1863, p. 136 *non* id. Sow.)

M. testa oblique-elongata, convexa, angusta, costis radiantibus rugosis ornata: costis ad marginem anteriorem paucioribus, ad marginem posteriorem prope obsoletis; striis concentricis inæqualibus, undulatis, interdumque lamellosis.

Shell very oblique and unequal; the anterior portion being much shorter than the posterior. The height is not considerable, but the thickness very great, and the beaks are much incurved. Strong radiating, rugose costæ ornament the shell, becoming weaker near the periphery and less numerous on the lateral terminations; they have usually no intermediate ribs between them. The striæ of growth become undulating in crossing the costæ and often lamellar near the periphery. The hinge is not different from the usual form in Macrodon, and, I believe, the sub-genus, or whatever it may be called, ought to be accepted, as the differences from Arca and Cucullæa are considerable and important. (*Vide* Morris and Lycett, Great Ool. pt. II, p. 48.)

The present species has been long known, and has been figured by Rev. W. Everest in Vol. XVIII of the Asiatic Researches. It cannot be identical with the Cutch *Cucullæa virgata*, Sow. (Trans. Geol. Lond. V., pl. 22, fig. 1) as this shell is not nearly so oblique, is

much higher and has far more radiating costæ of unequal strength; the hinge line equally does not correspond with that of our specimens. I have much pleasure in naming the species after *Philip Egerton, Esq.*, C. S., at present Deputy Commissioner of Umritsur, who placed his interesting collection, made in 1863 in Spiti, at our disposal for examination.

9. NUCULA, *sp.*, from Gieumal; resembles *N. subovalis, Goldf.* (p. 154, pl. 125, fig. 4), and does not seem to be a *Leda.*

10. NUCULA CUNEIFORMIS, *Sow.* (Geol. Trans. V., pl. XXII., fig. 4) is quoted already by *Mr. H. F. Blanford* from Spiti. It is one of the most common fossils, and occurs throughout the Spiti shales. It is certainly identical with the Cutch fossil, of which I have compared actual specimens with it. It is a very inflate shell like *N. Hammeri, Defr.* (apud Goldfuss), but usually found distorted by pressure of the rock.

11. CYPRINA TRIGONALIS, *Blanford* (Journ. As. Soc. Beng. 1863, p. 135, pl. IV., fig. 5). No better material has been as yet procured than was known from Mr. Blanford's notice. The shel lseems to be rare. It does *not* occur in the Gieumal sandstone with *Avicula echinata*, which statement rests upon a mistake with another species.

12. TRIGONIA COSTATA, *Park.* (Sow. Min. Conch. I, pl. 85). Two specimens found at Gieumal do not differ from the common oolitic fossil of Europe. They are somewhat broader, approaching to the variety *T. pullus*, Sow., which is not specifically different from the *T. costata.* It occurs as well in the oolitic deposits of Cutch.

13. ASTARTE UNILATERALIS, *Sow.* 1840. Trans. Geol. Soc., pl. XXII., fig. 14.—id. *Salter*, in Strachey's Palæont., p. 97, pl. XXIII., fig. 10.

The flattening of the umbones, to which Mr. Salter alludes, is very remarkable, and is to be observed on all the species from this district; it seems to be a local peculiarity. On the Cutch specimens, which are otherwise undistinguishable, this flattening does not occur, at least not to the same extent, and even the concentric ribbings are not nearly so strong. The species is very common throughout the Spiti shales, and occurs always with *Nucula cuneiformis*; the species has been often considered as *Astarte major.*

It must be this species which Prof. Oppel names *Astarte Harmanni* (Pal. Mith. 1864, p. 273); the Rev. Mr. Everest's figure certainly represents it, the original specimens of which are in the Asiatic Society's collection, Calcutta.

14. ASTARTE MAJOR, *Sow.* 1840. Geol. Trans., pl. LXI., fig. 1, is much longer or wider, and not as high as the previous species; it is also generally more inflated and has a deeper lunula.

This species is much rarer in Spiti, and has been only found at Gieumal.

15. ASTARTE SPITIENSIS, *Stol.* Pl. IX., fig. 9.

Ast. testa subtrigonalis, valde inæquilateralis, umbonibus superne applanatis, acutis atque incurvis; lunula ovali, profunda; superficie striis concentricis atque rugis crassis ornata.

A large subtrigonal shell, not much inflated, covered with unequal striæ of growth and sulci. The umbones are flattened and curved inside and anteriorly; the lunula is ovate, very deeply excavated and bounded with sharp margins. The area is long, and the bounding ridges are roundish. The periphery is only slightly and partially granulated. The teeth and grooves of the hinge do not differ from the usual form in Astarte.

This species somewhat resembles in form *Ast. subtrigona*, Goldfuss, (III. pl. 134, fig. 17), in which the anterior portion is more prolonged and the lunula not nearly so much excavated. The striæ of growth do not correspond very exactly.

Locality: Chikkim and Kibber.

16. ASTARTE HIEMALIS, *Stol.* Pl. IX., figs. 2-3.

Ast. testa subtrigona, complanata, rugis concentricis crassis ornata; lunula ovali-elongata, profunda; margine ad peripheriam obsolete atque partim granulato.

Shell ovate, somewhat trigonal, the anterior and posterior parts being extended and rounded; much compressed and covered with numerous coarse sulci, which terminate on the edges of the lunula and of the area; the latter is narrow and deep; the lunula rather elongated with sharp ridges. The peripherical granulation is sometimes clearly seen, sometimes it disappears altogether. The hinge does not exhibit any peculiarities, only the muscular impressions are proportionally of large size.

Locality. This species has been met with at *Kibber*, *Chikkim* and *Gieumal*, but it is rarer than any of the three others, which occur with it.

17. HOMOMYA TIBETICA, *Stol.* Pl. IX., fig. 4.

H. testa valde inæquilateralis, antice truncata postice elongata, ad marginem rotundata, utrinque hians; superficie rugosim concentrice striata.

The species is very characteristic in its form: the anterior extremity being very short, truncate obliquely, the posterior much prolonged and rounded at its termination. The lower margin is slightly curved, the hinge line nearly straight. The beaks are strongly incurved, and there is below them a prominent tooth in each of the valves exactly as in *Pholadomya*. The surface is covered with concentric striæ of growth only, which are coarser in the first stage of growth than afterwards. The shell is open on both sides.

Locality: Gieumal; three specimens have been found.

III. *Gastropoda.*

1. PLEUROTOMARIA, *sp.* Two species have been noticed in the Spiti shales, both only casts and not sufficiently perfect for further determination. The one species from Gieumal (*vide* Journ. As. Soc. Bengal, 1863, pl. 4, fig. 3) has more rounded whorls: the basis of the last whorl being covered with broad spiral sulci; and the band lies above the middle of each whorl.

The second species, found at Kibber, is more turrited and the whorls are more angular, having the band on this angle in about the middle of each whorl.

[*Turritella montium*, Blanf. Journ. As. Soc. Beng., 1863, p. 134, pl. 1, fig. 7. As regards the locality it is doubtful where this shell has been collected. I do not think in Spiti. The mineralogical character is different from anything I have seen, and one, the specimen figured by Mr. Blanford, is partly incrusted by a *Membranipora*, which, I would rather say, is younger than jurassic.]

IV. *Cephalopoda.*

1. AMMONITES ACUCINCTUS, *Strachey.*

1863. *Blanford* in Journ. As. Soc. Beng. p. 126, pl. 1, fig. 3.

1865. *idem* in Strachey's Palæontology p. 87, pl. 18, figs. 1-2.

The quoted descriptions and figures will be at present sufficient to recognize the Indian fossil. With regard to the sutures I may

notice, that fig. 1*c* in Strachey's Pal. pl. 18 gives no good idea of the true form of the lobes and saddles. The figure was evidently taken from a specimen with a very much eroded surface.

Prof. Oppel's lately published descriptions and figures of Himalayan Cephalopoda offer ample materials for comparison (1864, Palæont. Mittheilungen, Stuttgart). Among the many described species of *Ammonites* I would very much desire to draw attention to the following three species: *Am. Adolphi* (loc. cit. p. 270, pl. 75, fig. 1), *Am. substriatus* (loc. cit. p. 271, pl. 75, fig. 2), and *Am. Lymani* (loc. cit. p. 272, pl. 76, fig. 3). All these three forms, described under different names, come from the Spiti shales in Ngari Khorsum, and my present belief, based upon large materials from the whole of the northern Himalayas, and to a good extent from the same localities, is, that the three forms are identical in species. I may be excused in differing so far from the views of my friend Prof. Oppel, but I may be allowed also to say that scarcely anybody would accept proof to the contrary with more thanks than myself. Figures are always apt to lead into mistakes. Every palæontologist forms his opinions from a certain amount of materials, and nobody can pretend to be absolutely correct; but insufficient material prevents much the attainment of sound conclusions.

With regard to *Am. Adolphi* and *substriatus* of Prof. Oppel, neither the descriptions nor the figures shew any specific difference, and everybody will, I think, believe these two forms to belong to the same species. The sutures are in both the same, and are respectively perfectly identical with those of *Am. acucinctus*, so that it is not necessary to figure these again. *Prof. Oppel's* figures of the two above-named species represent specimens devoid of the shell surface, and in consequence of this circumstance the flexuous ribs are less distinctly marked, and the serrated keel altogether wanting. We possess perfectly similar specimens from the North of the Niti pass.

Am. Lymani is a less involute form. Prof. Oppel examined two specimens, one from Ngari (Gnari) and one from Gieumal (Gimul) in Spiti. They seem both to have had the shell surface preserved, and the keel as well as the lateral flexuous striæ of growth were distinctly visible. At Gieumal in Spiti I have collected among many other

fossils also numerous specimens of *Am. acucinctus* and several of these have exactly such a wide umbilicus as *Oppel's Am. Lymani.* I cannot see what other species the figure ought to represent, if not this largely umbilicated variety of *Am. acucinctus;* our specimens are decidedly not different from the type, as we have satisfied ourselves from a great number of specimens of different sizes. In *Strachey's* Palæont. (pl. 18, fig. 2,) this less involute variety is marked as *Am. ac.* var. *mundus.* Among the European species *Am. acucinctus* has a good many allies. Prof. Quenstedt describes in his "Cephalop. Deutschlands" and in the "Jura" several closely allied forms, to identify which could be of no value from want of the necessary materials. *Mr. Schafhœutl* described in his "Sud-Bayern's Lethæa geognostica" (1863, p. 415, pl. 83, fig. 3) an *Am. incisus,* from which, according to the characteristic description and figure, hardly a difference whatever can be traced out. *M. Schafhœutl* says, that the species occurs with *Planulati* Ammonites; this is also precisely the case with *Am. acucinctus* as the Spiti shales might be emphatically called the *Planulati* beds, because the *Ammonites* of this group are at least ten times more numerous than those of other groups, although they do not belong to many species. Finally, I would refer again to *Prof. Oppel's* "Pal. Mittheilungen," and for the present notice only the remarkable similarity of *Am. Pichleri* (loc. cit. p. 212, pl. 31, fig. 4), which appears to be the closest ally to the Indian shell. It is to be regretted, that the lobes of the species are not figured; the description does not explain them sufficiently.

I must say, for my own part, that I have no doubt whatever that *Am. acucinctus* will be recognized among the many similar European forms, among which a reduction in the number of their specific distinctions appears very desirable.

Locality. In the Spiti shales *Am. acucinctus* is throughout very common in the Spiti valley; Mr. Mallet brought in 1860 several good specimens from the North of the Niti pass, and *Col. Strachey* and *Messrs. Schlagintweit* collected the species numerously in the same beds in Ngari-Khorsum.

2. AMMONITES STRIGILIS, *Blanford*, 1863 Journ. As. Soc. Bengal p. 126, pl. 3, fig. 1.

This is a very remarkable species, to which there is no European ally known. Since the publication of the paper referred to Mr. Blanford has succeeded in tracing out another and more complete specimen from Dr. Gerard's collection. The specimen is evidently from the shales. The ribbings begin with the body chamber, and are exactly similar to those represented in Mr. Blanford's previous figure. The outlines of the sutures resemble those of the "Heterophylli." Lobes and saddles are uniform, and in size gradually decreasing towards the umbilicus. The first lateral lobe is longer than the dorsal, and all are similarly tripartite. The dorsal and the first lateral saddle are distinctly bipartite, the following approach more to tripartition; their branches are short, but they terminate clearly phylliform. We possess only one fragment from Kibber probably belonging to this species, but it is still quite smooth in a diameter of 65 millemetres.

3. AMMONITES MACROCEPHALUS, *Schloth.*

1850. *D'Orbigny*, Pal. Franç. Jur. I., pl. 430, p. 151, or *Quenstedt's* Ceph. Deutschlands, p. 182, pl. 15, figs. 1-2.—1863, *Am. Nepalensis*, Gray, Blanford in Journ. As. Soc. Beng. 1863, p. 123, pl. I., fig. 6.

The specimens from the Spiti shales belong chiefly to Quenstedt's variety *Am. mac. compressus.* Any of the European figures can be taken as a representation of the Indian fossil, and also Quenstedt's very carefully executed figure of the outlines of the sutures. I have compared French and German specimens of the same species with the Himalayan fossil, both as regards the form of shell and the sutures, *and can warrant their full identity. Am. macrocephalus* has as yet been found, in Spiti, only near Gieumal, in the lowest beds of the shales. The specimen figured by Mr. H. F. Blanford (loc. cit. and deposited in the Soc. collection) is most probably from the same locality. Mr. Blanford's identification of the species with *Am. Nepalensis*, Gray, rests upon his comparison of the Spiti specimens with Gray's originals in the British Museum in London. Gray's figure itself is very coarse, and would never allow us to recognize the species, as not only the ribs are much too coarse but even their direction does not agree well.

The specimen described by Mr. Blanford, as *Am. Nepalensis* in Strachey's Palæont. p. 77, pl. 14, fig. 1, is much more allied to Gray's figure, but it is still very indistinct. Mr. Blanford assures me that it is also identical with Gray's originals, and that he thought himself, in comparing the species in the British Museum, that they were identical with *Am. mocrocephalus.*

Mr. Mallet brought a few specimens of *Am. macrocephalus* from the North of the Niti pass in 1860; the specimens from here are usually larger and some are of equal size with Gray's figure.

4. AMMONITES OCTAGONUS, *Strachey.*

1863. *Blanford,* in Journ. As. Soc. Bengal, p. 128, pl. 1, fig. 5.

1864. *Am. Sömmeringi, Oppel,* Pal. Mith. p. 280, pl. 80, fig. 1.

1865. *Am. octagonus and Hookeri, Strachey,* in Palæont. loc. cit. p. 83, pl. 12, fig. 2, and pl. 17, fig. 1.

Only fragments of this species have been figured, and the descriptions are, therefore, equally not very sufficient. The Survey collection possesses complete specimens from the Spiti valley and from the Niti pass, but we must defer to another opportunity giving a new figure. The species is no doubt much allied to *Am. Eugenii,* Rasp. (D'Orbigny Pal. Franç. Jur. I, p. 503, pl. 187), although the ornamentation exhibits a good deal of difference. Young specimens of *Am. octagonus* are at least partly tuberculated, while those of *Am. Eugenii* are only transversally ribbed. The first two rows of tubercles (counted from the umbilical edge) are in *Am. octagonus* distinctly lateral, while in *Am. Eugenii* the second one of the two is much nearer to the middle of the back.

The well preserved surface of the shell of *Am. octagonus* exhibits numerous fine striæ of growth. It is usually the case, that the dorsal tubercles become somewhat more obliterate with the age, and are connected by short ribbings with the tubercles of the outer *lateral row;* these short ribs are always remarkably bent forward. In younger specimens, of which one is figured by Col. Strachey under the name *Am. Hookeri,* the partial obliteration of the dorsal tubercles does not occur often but it is sometimes the case, and intermediate non-tuberculated ribs are present in all stages of growth. Judging from our materials we cannot regard *Am. octagonus and Hookeri* as different species. The

fragment, which Prof. Oppel figures as *Am. Sömmeringi*, is from Spiti, and there is no doubt, I believe, of its being identical with similar pieces of this species, which we possess from different localities. I need hardly, I think, recall the resemblance which *Am. octagonus* bears to the upper liassic species *Am. Taylori*, Sow., and especially to the figure given by D'Orbigny in his Pal. Franç. Terr. Jur. pl. 102. If the tubercles on the umbilical edge of *Am. octagonus* disappear, as sometimes occurs on the last whorl and chiefly near the mouth, such fragments of whorls could, except from the size, be hardly distinguished from those of *Am. Taylori*.

5. AMMONITES HYPHASIS, *Blanf.* Pl. X, fig. 2.

1863. Journ. As. Soc. Beng., p. 132, pl. 4, fig. 2.

1864. *Am. Seideli*, Oppel, Pal. Mitth. p. 283, pl. 80, fig. 3.

1865. *Am. umbo*, Blanford, in Strachey's Palæont. p. 78, pl. 17. fig. 2.

The transversally ovate whorls with their peculiar ribbings and the large umbilicus are very characteristic for this species. Sometimes the ribs are very sharp and interrupted on the middle of the back, or they are continuous up to a slight depression along with the sipho. Longer and shorter ribs are often alternating, and some of the former rise towards the edge of the back to sharply elongated tubercles, and divide from these each into two, usually three, or even four ribs. The ribs very seldom form slight elevations at the point where they are interrupted near the middle of the back. There is besides no certain regularity which of the principal ribs becomes tuberculated, sometimes it is in young specimens every second or third rib, but mostly the fourth, although the intermediate ribs are not of equal length.

In *Am. anceps* or *Am. coronatus* the lateral tubercles are by far more numerous and regular and are placed nearer to the edge of the umbilicus. On the whole the shape of the whorls of the Indian fossil is more allied to the former than to any other known European species.

Mr. Blanford's original figure of the species represents a specimen with unusually small tubercles, and even these are mostly broken away ; the ribs are bipartite. The species can, no doubt, be only recognized with difficulty, and we have, therefore, preferred to give a new figure

on Plate X. There is certainly no mistake as regards the identity of *Am. Hyphasis* and *Am. umbo*, however different the figures of each may appear: of the former of which the originals are in the Asiatic Society's collection.

I do not think that I can be mistaken, in referring Prof. Oppel's *Am. Seideli* to the same species, the whorls in this last-named form are somewhat more compressed, but this is always the case with larger specimens, as we see on numerous fragments. *Am. Hyphasis* is not an uncommon species all through the Spiti shales, but usually only fragments are met with. Complete specimens of small size have been found at Gieumal and Kibber.

6. AMMONITES PARKINSONI, *Sow.*

1821. Min. Conchology, pl. 307. id. *Zieten, Römer, D'Orbigny, Quenstedt, Chapuis*, and others.

1863. *Am. Wallichii*, Blanford, in Jour. As. Soc. Beng., p. 127, pl. 1, fig. 4, and pl. 3, figs. 2-3.

1864. *Am Mörikeanus, Oppel*, Pal. Mitth. p. 281, pl. 80, fig. 2.

1865. *Am. Wallichii*, Gray. Blanford in Strachey's Palæont. p. 84, pl. 15, fig. 1, and pl. 19, figs. 1-2.

I tried hard to retain the Indian fossil, which was already described under so many different names, as a distinct species, but all my endeavours failed, and I fully believe now that there is not a single character which could be in any way satisfactorily used as a specific distinction. Most of the Indian specimens, which I have examined, belong to Quenstedt's variety *Am. Park. planulatus*, (Ceph. Deutsch. p. 143, pl. 11, figs. 2-3), having the habitus of a *Planulate* ammonite; not a single specimen of the inflated variety has as yet been found anywhere in the Himalayas.

The ribs bifurcate in our specimens generally about the middle of the sides, as usually in the Württemberg specimens, while those from the inferior oolite of Sully have the bipartition nearer to the back. Of the tubercles, which are often well marked at the bifurcations of the ribs, there are only slight indications in our specimens.

On the back itself the ribs are sometimes not so much bent forward as in European specimens, but they are always interrupted in the middle, their terminations being either opposite to each other or

alternate. The divisions of the sutures are quite identical, even in the details of the size of the different branches. The lobes are tri-,the saddles bi-,partite ; of the first lateral saddle the outer (*i. e.* near the back) branch is somewhat shorter than the inner, this being again bipartite. I observe the same peculiarity on several of the specimens which we possess from Sully in France. The German specimens are, as I said, especially like the Indian ; and there does not seem to me to be any necessity, nor is there any conchological or palæontological reason, which could justify a new name for the Indian fossil. It is, we are well aware, an important question, how and where to put a limit to variation, but it is, on the other hand, worse to attribute a specific value to differences which are only accidental, and variable in one and the same specimen.

Am. Parkinsoni is not uncommon near Gieumal and Kibber; it occurs in the Spiti shales in Ngari and North of the Niti pass as well. The beds with *Am. Parkinsoni* are known through all the jurassic deposits of Europe. I quote Gray's name of *Am. Wallichii* as a synonym only on Mr. Blanford's authority: Mr. Blanford tells me, that he compared the originals in the British Museum.

7. AMMONITES THEODORII, *Oppel.* Pl. IX, fig. 4.

1864. Pal. Mittheilungen, p. 280, pl. 78, fig. 3. (and fig. 2 ?) !

1865. *Am. Griffithii*, in Strachey's Palæont. p. 86, pl. 20, fig. 1.—non *Am. Griffithii*, Sharpe.

The characters of *Am. Theodorii* lie in the compression and small involution of the whorls, and in the lateral flexuous ribs, which rise from a tubercle on the edge of the umbilicus in bundles of three or four and terminate on the edge of the back each with a smaller tubercle. In the course of further growth the umbilical tubercles become either obliterate, or sometimes retain their strength. The dorsal tubercles are partly opposite partly alternate, and in large specimens they join with each other by short ribs across the back. Some of the ribs remain single, but occasionally they divide on the middle of the sides, except in old grown specimens.

The lobes are trifid, and the first lateral is longer than the dorsal lobe. The saddles are bipartite, the dorsal being the largest, then

follow two lateral and two or three obliquely descending auxiliary saddles, placed on the umbilical wall. As Prof Oppel (loc. cit.) remarks, that there exists in young specimens of *Am. Theodorii* a row of tubercles at the edge of the umbilicus, it is difficult to understand how fig. 2 (loc. cit.) ought not to belong to the same species, but to *Am. Spitiensis* (*Cautleyi*, Opp.). We have, therefore, preferred to give a figure of a small specimen, although Prof. Oppel refers to pl. 83, on which another representation of the Ammonite is to be published. Prof. Oppel has, however, kindly communicated to me, that he will stop for the present his publication of the Himalayan fossils, until my memoir is ready. The resemblance of *Am. Theodorii* to European forms, as *Am. Jason, ornatus* and *Duncani* is worth notice, especially when a larger material for the study of the Indian fossil shall have been procured. On the first whorls there seems to be an indication of a row of tubercles on the sides of the whorls; this row is placed, however, nearer to the back, where the ribs bend somewhat forward, and not on the middle, or near the umbilicus, as is usually the case in the above quoted allied species. In the form of the shell the kind of ribbing and the partitions of the sutures, the compressed variety of *Am. ornatus* from the Württemberg Jura seems to be the nearest ally.

Am. Theodorii is a rare shell in Spiti; Prof. Oppel's specimens were collected in Ngari-Khorsum.

I cannot say much as regards *Am. Griffithii*, Strachey, Pal. p. 86, pl. 20, fig. 1. In its general appearance the shell does not differ much from *Ammonites Sabineanus*, Opp. Mr. Blanford tells me, that there exists undoubtedly a row of small tubercles on each of the dorsal keels, and that the representation of the specimen is not very correct. He believes it to be identical with *Am. Theodorii*, Oppel.

In any case the name must be avoided, as it was long since used by *D. Sharpe* for a cretaceous and quite distinct species, which, although itself identical with *Am. planulatus*, Sow., equally from the middle cretaceous strata, does not admit of any further use of the same name.

8. AMMONITES SABINEANUS, *Oppel.*

1864. Pal. Mittheilungen p. 288, pl. 82.

1865. *Am. jubar* in Strachey's Palæontology p. 82, pl. 20, fig. 2, and pl. 21, fig. 1.

Prof. Oppel's and Col. Strachey's figures of this species represent several of the principal and characteristic varieties, and I shall mention for the present only a few peculiarities, in addition to those which have been noticed already. Our material amounts to about 50 different specimens.

The form of the shell is always pretty constant: the whorls being compressed, obtuse at the back, with a gentle slope from the middle of the sides towards the umbilicus, in which about half of the height of the previous whorls is exposed. The ribs are flexuous, always somewhat bent forward, but otherwise subjected to very much variation. In the first stage of growth the ribs are very fine, filiform, either single or bipartite, from the middle of the sides. On the back they bend strongly forward, either continuous or interrupted in the middle.

The few flat tubercles along the edges of the back appear generally somewhat later, when the specimen has assumed a larger size. They are, as has been noticed by Oppel and Blanford, very variable in size and number. Sometimes several of the ribs increase considerably in thickness along the edge of the umbilicus, and at shorter or longer distances from each other.

In other specimens the lateral ribs are from the first beginning stronger, and they become gradually thicker with farther growth, as seen in both of Prof. Oppel's figures and in Col. Strachey's figure 2 on plate 20. The sutures are figured well by Prof. Oppel and Mr. Blanford; they consist of one dorsal and one lateral saddle, and the rest are obliquely descending towards the umbilicus, all being bipartite; the lobes are trifid, and the first lateral is the largest of all.

Am. tenuistriatus, Gray, (in Strachey's Palæont. p. 78, pl. 15, fig. 2 *a-c**) bears so many relations to the fine ribbed variety of

* Judging from the sutures of a similar fragment, fig. 2 *d.* of the same plate, would not be a bad representation of the sutures; this seems, however, to be a misprint as to the numbers and letter, inasmuch as Mr. Blanford, p. 78, states, "the sutures are not visible."

Am. Sabineanus, that it is not unlikely only a fragment of this, as represented by Gray. There are at least several similar fragments in our collection, which certainly do not belong to a separate species.

Mr. Blanford considers the *Am. tenuistriatus*, Gray, as being likely only a variety of *Am. Nepalensis*, Gray. It is certainly not identical with the species, which Mr. Blanford calls *Am. Nepalensis* in Asiatic Society's Journal of 1863; this last-named form is undoubtedly identical with *Am. macrocephalus*, Schloth., as will be found mentioned under the head of the latter species. Until Mr. Gray's original specimens have been very carefully examined and compared, the explanation of this and the other figures will always remain a point of difference of opinions.

9. AMMONITES SPITIENSIS, *Blanf.*

1863. *Am. Spitiensis* and *guttatus*, Blanford., Journ. As. Soc. Beng., p. 131, pl. 2, fig. 4, and pl. 4, fig. 1.

1864. *Am. Cautleyi*, *Stanleyi* and *Groteanus*, Oppel, Pal. Mitth. pp. 279, 282 and 283, pl. 78, fig. 1 (non fig. 2 ?) pl. 79, pl. 80, fig. 4.

1865. *Am. guttatus* and *scriptus*, Blanford, in Strachey's Palæont. p. 79, pl. 13, fig. 2, and p. 81, pl. 16, fig. 2.

It was not until after much hesitation and repeated comparison of large materials, that I was led to believe that all the names quoted above have been attributed to mere varieties of one and the same species. I would not like to impress this opinion upon any one who is obliged to derive descriptions from single specimens, or to judge only from the figures which have been given. Most of them seem to represent such different characters, that it is difficult to understand how the respective forms ought to have any connection at all.

The following are the characters common to all varieties:—

The involution extends to about half of the width of each whorl, the umbilical edge of which is provided with a row of transversely elongated tubercles; from these rise bundles of two, three, or four, ribs proceeding with a slight bending, either single or sometimes again bifurcating, towards the back. This is crossed by them with a strong curve forwards. On the middle of the back the ribs become often somewhat thinner, but except on the body whorl we have never ob-

served them quite obsolete. Two or three deep transverse furrows, marking the previous positions of the mouth, are visible in the circuit of one volution, they are always bounded posteriorly by stronger swellings, which are much bent forward, especially on the back. The sutures are divided into one dorsal, two lateral and two or three auxiliary lobes, (very seldom only one is visible). All the saddles are bit, the lobes tri-,fid. In the dorsal saddle the outer branch (towards the periphery) is invariably longer, in the first lateral it is usually the inner branch. The second lateral saddle is shorter and obliquely placed towards the first; it lies on, or very close to, the umbilical edge, while the two (or sometimes three) auxiliary saddles lie on the wall of the umbilicus.

The principal variation is in the thickness of the whorls. If it were possible to account for any other variable characters which would always accompany the former, we might be justified in distinguishing and characterizing one or two similar forms as quasi-species, but for this opinion I am unable to discover any support in our material. The section of the whorls varies with gradual alterations from round or broadly-ovate to oval in the direction of the height of each whorl. These alterations can be often traced to a certain extent on one and the same large specimen; however local varieties seem to be indicated, as for instance in Spiti the varieties with rounded whorls occur chiefly at Gieumal, and those with more compressed whorls near Kibber, at the other end of the jurassic ellipse. In Ngari both the varieties occur as well; and also North of the Niti pass, whence many specimens were brought down, in 1860, by Mr. F. R. Mallet. The number of tubercles on the umbilical edge varies from 15 to 22, it is, however, independent of the thickness of the whorls and sometimes greater, at other times smaller, in compressed specimens. The ribs are very constant as regards their direction; and their number in one bundle increases usually with the growth of the shell.

The height of the saddles is variable, and equally so the respective length of their branches, but their width is always greater than that of the lobes. Specimens with thicker whorls have the saddles often shorter, but this does not occur constantly, and besides it is well known that the height of the sutures generally decreases with the approach to the body-chamber.

A comparison of Prof. Oppel's *Am. Stanleyi* and *Groteanus* will, I believe, if the size be abstracted, leave no difficulty in their being recognized as the same species, and as identical respectively with Mr. Blanford's original *Am. Spitiensis*. Specimens from the same localities, as those of Messrs. Schlagintweit and Mr. Blanford's originals, being compared leave no doubt about this point.

Mr. Blanford's original figure of *Am. guttatus* represents a specimen* which stands intermediately between his *Am. Spitiensis* and Oppel's *Am. Cautleyi*. (Of the latter I refer merely to fig. 1, as I rather believe that fig. 2 represents a fragment of *Am. Theodorii*, Opp.). Mr. Blanford separated his *Am. guttatus* from *Am. Spitiensis* chiefly on account of the somewhat higher divisions of the sutures, and after referring to some slight differences in the ornamentation, he says (loc. cit. Journ., p. 131) "these latter differences I consider, however, to be unimportant, and should further specimens shew the sutures to be more variable than is usual in Ammonites of the same group, there would remain no good reason for distinguishing the two forms in question." Now I hardly need to notice anything more about the variations of the sutures than I have already stated. We possess from Kibber several specimens quite similar to *Am. Cautleyi*, Oppel, and I can only refer to my previous remarks as regards the alterations in the thickness of the whorls, to shew that we have most probably to deal only with a variety. Of course, if the compression of the whorls is to be accepted as a specific difference, then we have to grant immediately not only the independence of all the quoted synonyms, but we have to establish about half a dozen more of such temporary species. This is, we believe, not only not necessary, but in reality injurious even to the geologist. The figure of *Am. guttatus* in Strachey's Palæontology I can quote only on Mr. Blanford's authority as a synonym; nobody could recognize the species from this figure. Mr. Blanford says, p. 79. "the restoration herewith given on pl. 13, fig. 2 is consequently erroneous, the diameter of the whorls being probably at least half as much again," &c.

With regard to *Am. scriptus* (loc. cit.) there cannot be much doubt, that the fragment figured belongs to *Am. Spitiensis*, namely to one of the less compressed varieties. The outlines of the sutures shew

* It is deposited in the Asiatic Society's collection, Calcutta.

no difference, except that they are more deeply incised. We possess, however, specimens on which the partitions of the saddles go so far that some of them become laterally cut into two parts. Of European described forms, which are similar to the Indian fossil, there are especially two lately decribed by Prof. Oppel in his "Palæont. Mittheilungen, 1864, pl. 66, figs. 1 and 6. I would mention nominally only a Crimean species *Am. Theodosia*, described by Deshayes. 1838, in the Mem. Soc. Geol. de France, tom. III, pt. I, p. 32, pl. 5, figs. 23-24. This Ammonite resembles very much some of our compressed varieties, and a closer examination of the original specimens would be very desirable.

Am. Spitiensis is a common shell in the Spiti-shales, where they occur along the northern slopes of the Himalayas.

10. AMMONITES CURVICOSTA, *Oppel.*

1849. *Am. convolutus parabolis*, Quenst. Cephalop. Deutsch. p. 169, pl. 13, fig. 2.

1852. *Idem*, Kudernatsch in Abhandlg. d. k. k. Geol. Reichsanstalt, Vienna, vol. I, p. 14, pl. 3, figs. 7-10.

1858. *Am. curvicosta*, Oppel, Jura-formation, p. 555.

1864. *Idem*, Seebach, Hannoversche Jura, Berlin, p. 155.

We possess only one, but that a perfect specimen, which has been found at Chikkim in the Spiti shales. The tubercles near the periphery are only indicated, but the corresponding thickened ribs are distinctly expressed. The specimen agrees perfectly with those from Swinitza in the Banat, whence it was brought to notice by the late Kudernatsch. Oppel's designation of the form with a new name is, we believe, justified, and the species has nothing to do with *Am. Bakeriæ* or *Am. perarmatus*, Sow.

The species has for many years been well known from the brown Jura of Württemberg, Suabia, and other places in Germany. It has been lately noticed by Seebach from the beds of *Am. macrocephalus* at the Porta Westphalica in Hanover. We see it in Indian rocks occurring in the same beds; the species seems to be, however, much rarer than many others of the *Planulati* group.

11. AMMONITES BRAIKENRIDGII, *Sow.* var.

1818. *Sowerby*, Min. Conch. vol. II, p. 187, pl. 184.

1849. *D'Orbigny*, Pal. Franç. Terr. Jur. I., p. 400, pl. 135, figs. 3-5.

1858. *Oppel*, Juraf. p. 377.

1863. *Am. torquatus*, Blanford, (*non* Sow.) Jour. As. Soc. Beng. p. 130, pl. 3, figs. 6-8.

1865. *id.* in Strachey's Palæont. p. 80.

Having compared specimens of *Am. Braikenridgii* from Bayeux with the Himalayan forms, we are unable to find any essential differences. The tubercles at the partitions of the ribs are only very seldom indicated in our specimens, but we see that quite similar variations exist among the specimens from Normandy. The species retains always the narrowness of its whorls, and the increase in the width of the section is very gradual. In large specimens of ours (about 100 mm.) the ribs become very thick. The indentations by the preceding whorls are always not considerable. The divisions of the sutures resemble much those of *Am. Humphriesianus*, as noticed by D'Orbigny. The lobes are tri-,the saddles bi-,partite, and of the branches of the dorsal saddle the outer (nearer to the back) is the longer, while on the first lateral saddle it is the inner branch. Quite similar divisions exist in compared specimens of *Am. Martinsii*, D'Orb., from Niort, and, besides the smaller width of the whorls of the latter species, I really do not see any specific difference. The deeper furrows, which marks the previous positions of the mouth, are the same in our specimens as in the Niort fossil. From specimens of *Am. Braikenridgii* from Bayeux, the single difference consists in the longer first lateral lobe, which in our Himalayan forms is invariably shorter than the dorsal lobe.

Localities. Common at Gieumal, rarer at Kibber, Longja and other places.

12. AMMONITES NIVALIS, *Stol.* Pl. X, fig. 1.

Am. testa discoidea, complanata; umbilico minimo; anfractibus lateraliter sublævigatis, ad peripheriam tuberculato-costulatis; dorso

obtuso. Suturis lateraliter quinque lobatis; lobo dorsali brevissimo, laterali primo maximo; lobis tri-,sellis bi-,partitis.

Proportions calculated from figured specimen (the diameter being taken as 1·00) in diameter of	...		...	·50 mm.
Outer whorl : whole diameter	...	...	...	0·52
Width of umbilicus : ditto ...	...	...	...	0·16
Width of the section : height	...	...	...	0·53

A discoid shell with involute whorls, so involute that only a very small portion of the inner volutions are visible in the narrow umbilicus. The greatest thickness of the whorls is near the middle of the sides, on which only striæ of growth are distinctly visible. On the edge of the somewhat roundish back there are numerous short costæ, which very soon disappear towards the umbilicus. The edge of the umbilicus is rounded and its walls are perpendicular. The sutures are divided similarly to those of species of the *Dentati* group. All the saddles are bipartite, gradually decreasing in size towards the umbilicus; the dorsal lobe is the shortest and the first lateral the longest; all the lateral lobes are tripartite, but not nearly so fine and filiform as in *Am. acucinctus.*

Locality: Kibber in Spiti; the figured specimen was found in 1861 by W. Theobald, Esq., Jun.

13. AMMONITES LIPARUS, *Oppel,* 1864. Pal. Mitth. p. 220, pl. 59, fig. 1.

The species is well known from the upper beds of the middle jurassic strata of Germany. Zieten's figure *Am. inflatus,* (pl. 1, fig. 5) is insufficient, but Quenstedt's representation appears to be characteristic.

There can be no doubt, that our Himalayan form agrees perfectly with Oppel's figure and description of the species. All the fine transverse striæ of growth and the divisions of the sutures are perfectly identical. Prof. Oppel forms another species, *Am. circumspinosus,* (ibid. p. 222), with which *Am. inflatus-macrocephalus,* Quenstedt. (Ceph. pl. 16, fig. 14, and Jura pl. 75, fig. 8) ought to be identical. It is no doubt difficult to form an entirely satisfactory opinion from figures alone, however it is certain that Quenstedt's figure of *Am. inflatus-macrocephalus* in his Cephalopoden, pl. 16,

fig. 14, does not shew any difference from Prof. Oppel's figure of *Am. liparus;* the former is evidently a cast and exhibits therefore the umbilical tubercles very slightly. The lobes are exactly the same.

Finally, I would still draw attention to *Am. Altenensis*, D'Orb. (Pal. Franç. Jur. pl. 204), from which Prof. Oppel has distinguished his *Am. liparus* and *circumspinosus*. There can be no doubt that from the existing figures the species might be kept separately, but we must remember that in *Am. Altenensis* the tubercles on the edge of the umbilicus become also a little farther distant from the edge, and that if they cease in *Am. liparus* to project upon the space of the umbilicus, we are at a loss for any reason for separating these two (the French and German) species.

Locality. In the Spiti shales near Kibber ; rare.

14. AMMONITES TRIPLICATUS, *Sow.* 1821, Min. Conch. Vol. III, p. 167, pl. 292.

Morris in his Catalogue (p. 295) quotes the species from the Kimmeridgian. Roemer, Quenstedt, (Ceph. pl. 13, fig. 7), and others have identified the German middle-jurassic species with the English. Oppel (Jura-formation p. 550) proposed a new name for the German forms, (*Am. funatus* ; *vide* also *Seebach's* Hannov. Jura. p. 155), without any critical ground whatever, simply because he says that Sowerby's species belongs to the upper Jura. We cannot at present go so far as to account for all the numerous variations of the species, which have been noticed by several observers previously. The species is always thin ribbed in the first stage of growth, but the whorls are either thicker or more compressed. The ribs are always curved from the umbilicus towards the periphery. Large specimens have the last whorls always somewhat compressed and usually higher than broad. The ribs divide here often into four instead of three. Kudernatsch noticed several of the most marked varieties from the Banat, and we would refer here to his description in the first volume of the Abhandlungen der k. k. Geol. Reichsanstalt, Wien, 1852, p. 15, pl. 4.

Certain it is, that the numerous Himalayan specimens are quite identical with those from the Brown-Jura near Locken in Württemberg

and those from Swinitza in the Banat. From what I know of the English *Am. triplicatus*, I cannot see any good reason to justify the separation of these forms into species. Until more decisive proof is given, we do not think it advisable to accept the *Am. funatus*.

Am. triplicatus is very common all through the jurassic shales of Spiti, we have it represented in about 60 specimens in different stages of growth, and of great variation. Col. Strachey found it not less numerous North of Kumaon in Ngari Khorsum and at Niti.

15. AMMONITES BIPLEX, *Sow.* 1821, Min. Conch. Vol. III., p. 186, pl. 293, figs. 1-2.

There is no possibility of distinguishing specifically between the specimens of this species from *Aylesbury* and those from the *Himalayas*. The ribs never become tripartite, (even in our specimens of 200 mm.), except occasionally near the transverse furrows, which indicate previous stages of the mouth. The whorls increase very little in height, and are often flattened on the sides. It is nearly impossible to distinguish between young specimens of *Am. biplex* and *Am. triplicatus*, the ribs are in both equally fine and bipartite, but they seem to be always more bent forward in the latter species.

It would be hardly possible to go through all the forms which have been, in Germany, by different authors and at different times, attributed to Sowerby's *Am. biplex*, but, I believe, that there are very few English palæontologists or geologists to whom Sowerby's meaning of *Am. biplex* was and is unknown. *M. Seebach* (Hannoversche Jura, 1864, p. 157) proposes for it the name *Am. Kimmeridgiensis*, and says (loc. cit., p. 156) that it appears to be best to abolish the name *Am. biplex*, Sow., altogether. This is certainly a novel proceeding! If we first knew the meaning of all the species which have been in Germany mistaken for *Am. biplex*, Sow., we might be justified in proposing and correcting others, but the matter is by no means settled by proposing a new name. By far the greatest confusion exists among the German forms.

The specimen figured by Mr. Blanford as *Am. biplex* in the Jour. As. Soc. Bengal, 1863, pl. III. fig. 4, is not *Am. biplex*, but a thin-ribbed variety of *Am. triplicatus*. The figures 1 on pl. 11 and 12 in Strachey's Palæontology are correct.

Am. biplex, Sow. (as identical with the English Kimmeridgian species) is, although not so common as *Am. triplicatus*, still plentifully to be found everywhere in the Spiti shales, and is usually the associate of the last-named species.

16. AMMONITES ALATUS, *Strachey*.

1865, in Palæontology loc. cit. p. 76, pl. 18, fig. 3.

The principal distinguishing character of this species, as has been already noticed by Mr. Blanford, is in the transverse elliptical section of the whorls being wider than high. The quoted figure "is compiled from two fragmentary external casts," as stated by Mr. Blanford, but unfortunately all the undulations of the transverse striæ have been left unnoticed, or they were perhaps not visible. In our specimens they are seen exactly like those of *Am. Eudesianus*, D'Orb., (Pal. Franç. Jur. p. 386, pl. 128), with which also the divisions of the sutures principally agree. The French species differs by a smaller number and more rapid increase of the thickness of the whorls. *Am. Adeloides*, Kudernatsch (in Abhandlg. d. k. k. Geol. Reichsanstalt, Wien I. 1852, p. 9, pl. II, figs. 14-16) cannot be much different from *Eudesianus*, and is probably a local variety only. *Am. Adelæ*, D'Orb. (loc. cit. p. 495, p. 183) cannot stand a close comparison either with *Am. Eudesianus*, or with the Indian fossil, if D'Orbigny's figure and description of the species is correct.

The nearest ally to the Himalayan species is, so far as I remember, a Fimbriate *Ammonite* which I have several years ago collected with my friend Prof. E. Suess at the village Wyeska near Puchow in the valley of the Waag river, in N. W. Hungary. We let it pass, I think, at that time for *Am. Adelæ*, and under the same name it is probably quoted by Dionys Stur in the "Jahrbuch" of the Geological Institute, Vol. XI, 1860, p. 42. A closer examination seems to me very desirable.

Am. alatus is a rare species in Spiti, I met only with one specimen North of Kibber.

17. ANISOCERAS GERARDIANUM, *Stol.* Pl. X, fig. 3.

A slightly curved fragment, somewhat spirally turned, ornamented with distant and very oblique ribs. These are a little weaker in crossing the ventral region, but not fully interrupted; along the sipho or the dorsal region there is also a slight impression visible

on the interruption of the ribs marked by small tubercles. The sutures consist only of four saddles and as many lobes : the former are all bipartite and nearly equal in size ; of the lobes the dorsal is bi-,the other tri-,partite, the former is the deepest of all.

The tendency to a spiral involution, which cannot take place in one and the same plane, shews clearly that this and several other similar jurassic and cretaceous species cannot belong to *Ancyloceras*, to which they are usually attributed. The single specimen is the first of this genus known from the Himalayas ; it is undoubtedly from the Spiti-shales, but the exact locality is not noticed ; it was collected by Capt. Hutton.

18. BELEMNITES CANALICULATUS, *Schlotheim*, 1820.

Bel. sulcatus, Miller; *Bel. Altdorfensis*, Blainv. *Bel. Bessinus*, D'Orb., etc.

1863. *Bel. sulcatus*, Blanford, in Journ. As. Soc. Bengl., p. 125.

1864. *Bel. Gerardi*, Oppel, Pal. Mitth. p. 273 (?).

1865. *Bel. sulcatus*, Blanford in Strachey's Palæont. p. 76, pl. 10.

Mr. Blanford was, I believe, quite correct in referring the specimens (from the Spiti shales) in Dr. Gerard's and Col. Strachey's collections to the above-named species. There is no possibility of distinguishing them (except their usual large size) from the English, French, or German specimens of the same species from the Oolite.

We do not possess very good specimens from the Oolite* of Cutch, but the fragments do not exhibit any difference from the Himalayan, and I believe Sowerby's determination (in Trans. Geol. Soc. V. pl. XXII, figs. 2-3) was a correct one.

It is probably for this species, that Prof. Oppel has lately proposed the name *Bel. Gerardi ;* I cannot at least think what other "*Canaliculate*" it could be. Everest's figure (Asiat. Res. XVIII. pl. I. f 17) to which Dr. Oppel refers, represents no doubt this species ; the originals are in the Asiatic Society's collection.

Localities. The species is to be met with in the Spiti shales, wherever they occur. Large alveoli of 6 inches in length are not

* Many Cutch fossils, which I have lately seen, are identical with species from Bayeux ; such as *Trochus duplicatus*, *Opis similis*, etc.

uncommon, and with these, guards the thickness of which exceeds sometimes one inch.

Bel. canaliculatus can be collected at many places in Spiti on the boundary of the shales and the Tagling limestone loose, with the three species which I have described from the Lias. I am here at a loss to determine, whether the species really occurs in the limestone. I do not see any impossibility, that it may have existed previously to the deposit of the shales, but I have no certain evidence, as all my endeavors to trace a specimen in the limestone itself failed. Moreover I found South-west of Chikkim, with the three previously described species, many specimens of true *Bel. canaliculatus.* One of these had a portion of the alveole preserved. In breaking this specimen I found the rock to be identical with that of the shales, and not with the limestone. This confirmed me in the belief that the *Bel. canaliculatus* is only washed out from the Spiti shales, and the species of the lower and upper beds are found together at present only in consequence of accidental mixture. We must accept this to be the real case, until we can prove the occurrence of the *Bel. canaliculatus* in the limestone itself, of which I do not see, as I mentioned before, any impossibility. The Spiti shales overlie Tagling limestone in most places without any intermediate beds, and this is in favor of either of these opinions.

19. BELEMNITES CLAVATUS, *Blainv.* (*vide* D'Orb. Pal. Franç. Jur. I., p. 103).

One well preserved specimen was found by myself in the Spiti shales near Longja. It is the only one I have seen from any part of India, and compared with French and German liassic species there is no possibility of finding the slightest difference. I will not say that more and larger specimens may not show some differences from the liassic types; however, Prof. Oppel (Juraf. p. 153) remarks, that similar forms extend to the lower oolite, but that they may possibly be separated from the true *Bel. clavatus.* On the other hand I wish not to assert, that the Belemnite occurs originally in the Spiti shales, it may have been washed out in the same way as was certainly the case with other species. But just at this locality the lower Tagling limestone is more than a mile off.

Section 7.—Upper jurassic beds.—Gieumal Sandstone.

On the Spiti shales rests a sandstone formation, which, from its usually light colours, forms a great contrast to the lower beds. Its thickness varies from two to about 600 feet, which it seldom exceeds. The principal mineralogical character of this sandstone is its siliceous element, which is in some beds so very prevalent that it is not easy to distinguish fragments of it from the carboniferous quartzites, which occur down below in the Spiti valley in the same vertical series of rocks. In some beds the sandstone forms a rather loose grit, or it is even coarsely conglomeratic. The colour is light yellowish. Somewhat darker beds are not uncommon, generally strongly carbonaceous and more compact. These calcareous beds are especially the seat of a great number of fossils, of which an *Opis*, one species of Oyster like the *Ostrea gregaria*, and *Avicula echinata* are very common, occurring associated in the same way as they do in the European jurassic beds; for instance at Nattheim. The Gieumal sandstone retains this character very constantly all through Spiti. Its extension is limited by the Spiti shales, and I have not observed it any where beyond the jurassic ellipse. South-west of Gieumal the lowest beds are seen partly interstratified at contact with the uppermost beds of the Spiti shales; this proves distinctly their close connection with these shales, although mineralogically they are quite different. The interstratification must be explained by undulations of the jurassic ground at the close of the deposit of the shales and in the beginning of that of the sandstone deposit. By far the greatest portion of the

sandstone rests conformably on the shales, and from the remarkable features which it presents it is necessary to distinguish it as a separate group. This *Gieumal sandstone* (called after the village Gieumal) occurs in the very same relative position, and of a perfectly similar mineralogical character, to the North of the Niti pass and in Ngari Khorsum. There is no doubt, that it has a further geographical extension, but subsequent researches have to determine what connection these widely separated deposits have with each other.

FOSSILS OF THE GIEUMAL SANDSTONE.

The following fossils have been observed near Gieumal, the same are to be met with, as has been stated, in several other places where the Gieumal sandstone occurs, but they are usually not so well preserved as to admit of satisfactory determination.

1. OSTREA, *sp.*, resembling the *Ost. gregaria,* Sow., of the Coral-rag; another species resembles *O. Sowerbii.*

2. GRYPHÆA, *sp.*, a coarsely ribbed species, with very thick shell, seems to be new; it is especially common at Chikkim station.

3. AVICULA ECHINATA, *Sow.* (Min. Conch. pl. 243.) The researches of the last few years all agree in the point, that *A. echinata* and *Bramburiensis,* Sow., are the same, and identical with *A. tegulata* and *decussata* of Goldfuss. I may say, that our specimens from the Himalayas are certainly identical with the original *A. Bramburiensis,* Phill. (*vide* Morris and Lycett). There seems no reason to separate the species from *A. echinata,* Sow., of which Morris and Lycett (p. 16) say, that the vertical range is very considerable. Morris in his Catalogue, p. 163, quotes it even down to the Lias.

None of our specimens shew the unequal ribbings, as represented in Goldfuss' *A. tegulata* or *decussata,* and they agree, therefore, much better with the English forms. It is evident that several questions about this interesting species are not yet settled. Our Himalayan specimens agree best with the Cornbrash species. Mr. Blanford

quotes it under the same name in Journ. As. Soc. Beng., 1863, p. 137.

4. MYTILUS MYTILOIDEA, *Blanf.* (Journ. As. Soc. Beng., 1863, p. 137, pl. IV, fig. 8, non *M. mytiloides*, Lam.) occurs with *Avicula echinata*. I have not seen any better specimens than that figured by Mr. Blanford. The anterior or lunular portion of the shell is somewhat concave and elongated-elliptical in shape. The species resembles very much *Mytilus tumidus*, Mor. and Lyc., (Great Ool. Foss. pt. II, p. 37, pl. IV., fig. 5) of the Great Oolite of *Minchinhampton Common*, and may be probably identical with it.

5. LIMA, *sp.*, a large species with concentric, lamellar striæ of growth only, much inflated; apparently new.

6. AMUSIUM DEMISSUM, *Bean*, (Pecten id. Geol. Yorksh. I, pl. 6, fig. 5). We possess only one specimen, this is, however, perfectly like Prof. Phillips' or Goldfuss' figures, and evidently the same which Rœmer figures as *Pect. vitreus* (Ool. pl. 13, fig. 7). D'Orbigny describes the species from the Russian jurassic deposits in Murchison's Russia p. 475, pl. 41, figs. 16-19. An interesting fact has been recorded (Zeitsch. d. Deutsch. Geol. Gesellsch. 1861. XIII, p. 400) by Mr. Trautschold as regards the difference in the ornamentation of the two valves in some species of *Pecten* (*Amusium*), namely, one of the valves having only concentric striæ of growth and the other radiating ribs. This may serve as a hint how very cautious we ought to be in naming new species.

7. PECTEN BIFRONS, *Salter, in parte* (Strach. Pal. pl. 22., fig. 5).

It is hardly necessary to say anything more than has been already stated on page 74. I do not know any European species which could confidently be identified with ours; but there are many described by *Goldfuss, Quenstedt* and *Buvignier*, which are closely allied.

8. ANATINA SPITIENSIS, *Stol.* Pl. X., fig. 4.

An. testa elliptice-elongata, transversa; subconvexa, inæquilaterali, antice parum prolongata, rotundata, postice maxime producta, caudata, subarcuata; superficie striis concentricis ornata postice radiatim obsolete. punctata; musculi impressione anteriori rotundata, ad dentem marginis cardinalis approximata; posteriori ovata, impressione auxiliari multo minore superposita; pallio integro.

Shell ovate elongated, with the greatest elevation along the caudate posterior extremity from which the shell slopes very gradually to the lower margin; the anterior side is very short and rounded. The hinge is prominent, and the cardinal process very strong. The anterior muscular impression is rounded, the posterior somewhat elliptical, with another small impression above it. The pallcal impression is entire, except a scarcely marked sinuosity, which it forms in crossing the ridge of the greatest convexity near the posterior muscle. The surface is covered with striæ of growth; only on a small portion near the posterior extremity a radiating punctuation is visible.

There is only one species, which seems to be like the Indian fossil *An. Bellona*, D'Orb. (Prod. I, p. 336) from the Callovien; but nobody can imagine what species D'Orbigny means to indicate by the few words which he had added to the name.

An. Spitiensis is a rare fossil, I have observed it only near Gieumal.

9. ANATINA, *nov. sp.* Another far more elongated species from the same locality; the anterior part measures about two-thirds of the posterior, so that the umbones are nearer to the middle. The surface seems to exhibit only striæ and sulci of growth. I am not aware of any European ally, but a full description must be deferred until better specimens can be procured.

10. OPIS, *sp.* Judging from a great number of casts the Himalayan fossil seems very like to *Opis Moreana*, Buvignier, but it has been as yet impossible to procure even one good specimen with the shell.

Section 8.—*Cretaceous rocks.*—*Chikkim limestone.*

At a few places within the extent of the jurassic ellipse there is a white limestone to be noticed, the stratigraphical position of which as regards the lower strata is very clear; it covers the tops of only a few hills.

The limestone, although on the weathered surface often purely white, is on a fresh fracture either somewhat blueish or greyish white, and if perfectly compact not bituminous; there are, however, strata which are somewhat earthy, and these give a strongly bituminous odour if struck with the hammer. I have traced these limestones only at three localities in Spiti.

On the top of the sandstone hill, South-west of Gieumal, there is a small portion of it at a height of about 16,500 feet. Its thickness hardly exceeds 100 feet, and the whole extent which, no doubt, has been once much larger, is only about 1,000 feet in length and about 200 feet in width. Above the small village *Tshissigaon*, somewhat near 16,000 feet, there is another portion of this limestone, it is here compact like that at the former locality, and isolated in three or four patches. The greatest thickness of this limestone, amounting to about 500 or 600 feet, rests on the sandstone of the Chikkim hill, near the village of the same name. It rises to an elevation above the sea of more than 16,000 feet. Its mineralogical character is the same as previously mentioned. The whitish color of the rock is so characteristic, that it can be instantly recognized from the yellowish colored *Gieumal sandstone* below it.

Not a trace of a fossil has been noticed at any of the other localities, except on the Chikkim station, where the age of the rock has been put beyond doubt. Several fragments of shells of *Rudistes* and numerous *Foraminifera* have been observed. The latter could be traced only on the weathered surface of the rock, and they belong all to genera which are represented in the cretaceous strata. It would be useless to undertake to name and describe new species, as they are, from their state of preservation, far too imperfect for that purpose. I shall, however, refer to some similar forms, from which an idea may be formed as to their character.

1. NODOSARIA, 2 *sp.*; shorter with thicker joints, resembling *N.*

intercostata, Reuss; and a longer species (up to and above 1 inch), very much like and, I should say, identical with *N. Zippei*, Reuss, from the Plæner of Bohemia.

2. DENTALINA *conf.* ANNULATA, *Reuss.*

3. ROTALIA, *sp.*

4. TEXTILARIA, 2 *sp.*; a slender one resembling *Text. anceps*, Reuss, and another much broader species.

5. HAPLOPHRAGMIUM, very like *H. irregulare*, Römer, sp.

6. CRISTELLARIA, *sp.*

The most common of these *Foraminifera* are one or perhaps two species of *Rotalia*, the *Textilariæ* and the *Haplophragmium*.

Section 9.—*Cretaceous.*—*Chikkim shales.*

Looking towards the Chikkim station from Kibber there is a change to be noticed in the colour of the top-beds, which appear somewhat dark yellowish as compared with the rest of the limestone. On examination of the spot a grey or darkish marly shale is to be found, in places very earthy. The whole thickness is not more than 200 feet, and probably even less. I have not been able to discover even a trace of any kind of fossil, nor have I seen these beds on any other spot in Spiti. From the great similarity of these shales to the limestone, especially at their contact, I am much inclined to believe that these marly shales are closely connected with the limestone and also of *cretaceous age*; but a satisfactory determination of these strata can be obtained only by the discovery of fossils, as there are no other beds above them from which their relative age could be even guessed.

CHAPTER IV.—*River and Lacustrine deposits.*

(Karéwah deposits of Capt. Godwin Austen.)

After the last marine deposits in Spiti—*the Chikkim shales*—an immense period followed during which the atmospherical(meteorological) waters have been labouring to change, disfigure, and to destroy what a far longer lapse of time had endeavoured to erect; I mean principally the action of the rivers in the formation of valleys and deeply-cut ravines. There can be no doubt, that the present depth of the valleys has been attained only in the course of time, and that the rivers did flow at a far higher elevation than they do at present. I observed opposite Shalkar, on the left bank of the Spiti river, flat and rounded pebbles of the red quartzitic sandstones of the *Muth series*, and of the greenish sandstones of the *Bhabeh series* at an elevation of about 1,500 feet above the present level of the river-bed. It is evident that these could come only from the Pin valley, or from any of the western ravines further to North. From the Para valley or the Ghu stream not a single pebble of this description is brought down. This is, so far as I know, the highest point of the occurrence of rounded pebbles in Spiti, although they may be possibly traced still higher. Above and round Shalkar and near the mouth of the Para and Ghu rivers there have to be noticed extensive beds of a fine yellowish clay, it is in places hardened by calcareous matter to a compact marly stone. Generally no clear stratification is perceptible, however sometimes the clay occurs laminated or even at a few places, as a little South of Shalkar, in thin beds. These clay

deposits are to be found throughout the Spiti valley, but usually at a higher level and in those parts of the valley which are much broader than others. We can, from this, justly suppose that these places were, by the widening of the waters and in consequence their decreasing velocity, more fit for the deposits of the finer materials which have been brought down from all sides by the glacier streams. I have spent hours in search after any kind of organic remains in these clays, and have, to my great distress, not found even a trace of a shell either in the neighborhood of Shalkar, or on the Para river, or in any other part of Spiti, as for instance below Drangkhar. Dr. Thomson (Travels, p. 117) mentions from a sandy bed near Kyuri (Kuri) a *Lymnea* and a *Planorbis*. The *Lymnea* is still living in great quantities in small tanks near Shalkar and Thabo, and at a higher elevation in a stream near Drangkhar, being much smaller at this last locality than at the others.

I am not aware of any living *Planorbis* in Spiti, but I procured a few small *Helices*, *Pupa* and *Nanina*. All these shells have been previously noticed by W. Theobald, Esq., Jun., in his notes, etc. (Journ. As. Soc. Beng., 1862, pp. 509 and 520.) Great numbers of shells have been discovered by Dr. Thomson on his travels in the North-west Himalayas, and also by Genl. A. Cunningham, and lately by Capt. Godwin Austen.

The large alluvial plateaux on the river banks, chiefly consisting of boulders of different rocks, are generally not more elevated than about 400 feet above the present level of the river. They are found all through the course of the valley, especially along the Spiti river in its wider portions. They are either loosely adherent or hardened to a kind of conglomerate. These deposits are seen sometimes in several terraces one above the other; the greatest number which I observed was five, and often the second one from above was the most extensive, but this differs according to the locality.

The large blocks, which occur in the alluvial deposit, are the cause of peculiar columns, which resemble the glacier tables and erratic blocks. The finer materials round a block are constantly washed away, while those below the block are protected from the direct action of the atmospheric waters. In this way all the different fantastic pinnacles of Dr. Gerard and other travellers have been and are still being formed. For more particulars I would refer to Capt. Godwin Austen's notes in the Quart. Jour. Geol. Soc. Lond., 1859, XV, p. 224, where a few representations of the principal features of similar deposits are given. Besides the direct action of the waters the great accumulations of debris must be attributed to large snow beds, which seem to have been, at least partly, the cause of extensive slips of mountain sides. Calcareous waters have occasionally with their solutions cemented these accumulations to a perfectly hard rock, as is to be found in places round Drangkhar. This town is built on ground which seems to be an immense slip of the western portion of the adjoining mountain. It seems to have resulted from the combined action of the flowing waters below and probably great masses of snows above.

PART II.—GEOLOGICAL FORMATIONS IN RUPSHU.

Sections in Rupshu.

The section across the province Rupshu is represented in Fig. 3, Pl. II. it leads from South to North-east by north, from the Spiti boundary on the Parang pass to the village Sungdo on the Indus. The southern part of Rupshu belongs stratigraphically to the large secondary basin of Spiti, and we find, with very slight alterations, a repetition of all the older formations which have been previously described. The middle and northern parts of Rupshu are occupied by metamorphic and gneissose rocks, and then follow, after a slight interruption, Serpentine rocks, and unaltered, greenish and reddish, stratified rocks. To avoid many repetitions of what has been previously stated on the one side, and on the other not knowing this portion of the country to the same extent as the southern, I believe it will best answer all required purposes to state briefly the formations in the same order as they are followed in the section from South to North. When I have been able to obtain more extensive information from the northern parts of Ladak, I shall endeavour to give a more satisfactory account of the geological features of that country: for the present the section may give an idea of what is to be expected, and how much is still to be done.

CHAPTER V.—*Secondary formations in Rupshu.*

1. Upper Tagling limestone.

Starting from the southern frontier of Rupshu we met the upper Tagling limestone on the top of the Parang pass, as previously described, with characteristic fossils of the middle liassic strata of the European Alps. In

descending down from the Parang pass not much can be said from direct observations. The greatest portion of the descent is covered with a large glacier or extensive snow-beds. Besides the weather was, as usually, too unfavorable to permit any examination of even the loose blocks which were lying all round. On the Tagling pass the whole ridge of the Bara-Latse range consists of the Upper Tagling limestone, and *Belemnites* are sometimes to be met with.

The Parang glacier descends on the northern side to something less than 17,000 feet, and opposite to its termination the secondary limestones are seen in great contortions pressed against greenish sandstones and white quartzite, probably of carboniferous age. In proceeding down the Para valley very extensive accumulations of debris occur on both sides of it; and it is sometimes impossible to ascertain what rock is *in situ* and what has been brought down by the river, or rolled from the sides of the valley. As it is hardly to be expected that a traveller could climb up every lateral ravine or mountain side, the examination of the rocks is a little doubtful in places, and I would by no means insist upon the boundaries marked in my section, as being *absolutely* correct. These have been defined more from the distinction of the strata, as they are represented on the large scale. Due attention has been of course paid to the debris, especially when it contained any fossils, and it has always been attempted to ascertain the original site of the blocks. As has been previously stated, the carboniferous rocks appear in dome-form under the limestones South and North of the Parang pass, and with these strata all those above have been more or less affected by the disturbance. We passed over debris of rocks of very different description, and often met blocks of upper Tagling limestone with the characteristic Gastropoda, until we reached the camp Tatang-yogma.

A few hundred yards North of this camp the lower Tagling limestone is found *in situ*. It is again chiefly a brown oolitic or somewhat arenaceous limestone, weathering of a rusty brown on the surface, and in some places containing numbers of fossils. We met here with a band of the limestone, which almost exclusively consisted of *Terebratula gregaria*. Of other fossils have been noticed *Terebratula pyriformis*, *Rhynchonella Austriaca* and *variabilis*, and besides a few fragments, a little specimen of an *Ammonite*, resembling *A. macrocephalus*. *Bel. bisulcatus*, n. sp., is not very common, and it is difficult to obtain good specimens. The beds in which these fossils occur dip at an angle of only about 20° to south-west, and continue so still farther to the north. Taking the Tagling limestone, on the whole, we do not think we under-estimate its thickness at about 2,000 feet, of which somewhat less than the half may belong to the lower and the rest to the upper beds.

2. Lower Tagling limestone.

A few miles North of the camp Tatang-yogma a considerable change in the character of the rock takes place. We come upon the blue earthy and strongly bituminous limestone, which is characterised by *Megalodon triqueter* and *Dicerocardium Himalayense*, and which I have previously described under the name of Para limestones. *Neoschizodus*, *Isocardia*, a few small *Gastropoda*, and occasionally some *Lithodendron-like corals* are to be met with, but nothing in such a satisfactory state of preservation as to admit of specific determination. The *Megalodon* and *Dicerocardium* are very characteristic for this series of limestone, the large cordiform sections of their thick white shells make them very easily perceptible even to an inexperienced eye. The dip of the Para limestone, the thickness of which I would estimate between 1,200 and 1,500 feet, is chiefly to south-west varying between 20 and 50 degrees. Disturbances and contortions

3.—Para limestone.—Rhætic.

occur, but they are not very considerable and are more local. I have already mentioned that the thickness of the Para limestone decreases considerably towards the south, and that it seems to thin out altogether in the southern and south-western parts of the Spiti-valley. Its geographical extent is no doubt by far greater in Rupshu than in Spiti.

The Para limestone, which we have previously referred to the Rhætic formation, extends to the north as far as a few miles south of the camping ground "Palang-balda."* Before reaching—on our descent in the Para valley—the Palang-chu, a large tributary of the Para river from the south-east, we come, below the characteristic Para limestone, upon a white band of compact limestone, conformably underlying the former, although partly much disturbed. I have not observed any other fossils in it than great numbers of *Corals*, and occasionally some small *Gastropoda*. I can hardly imagine, that we could have anything else than triassic limestone of the Lilang series below the Rhætic formation. The question is more doubtful, whether this white band of limestone ought to be referred to the former or to the next series. The more common occurrence of similar Lithodendron-like Corals in the limestones below the Rhætic beds proper seems rather to indicate their assignation to the lower, or the triassic series.

White band of limestone.

Again a great thickness of limestone follows in proceeding farther to the north. I have not succeeded in tracing here any fossils in it except Corals. From the very great similarity with the triassic limestone in Spiti, and from its stratigraphical position, I have no hesitation in attributing this

4.—Lilang limestone.—Trias.

* I must remark here, that the section in Fig. 3 is taken a little to the West of the Para valley, proper, to which our observations have been chiefly confined. However, there can be, no doubt, such a slight difference if any, from the section which I am describing in following the course of the Para river, that it is of no consequence whatever for the general idea of the geological structure, and a change would only complicate the representation.

limestone to the Lilang series. The limestone varies considerably, as before described, in its color and composition. It is often grey or whitish and compact, or black and dolomitic or even shaly. These latter beds are very earthy, and exhibit in places a kind of bacillar structure, which seems to be the first effect of metamorphism noticed to the South of the great mass of metamorphic rocks which occupy the middle portions of Rupshu.

CHAPTER VI.—*Palæozoic deposits in Rupshu.*

5.—Kuling series.—Carboniferous.

Next below the Trias we have to mention beds, which can only correspond with the Kuling or carboniferous series. The beds are only a few hundred feet thick, and consist of greenish sandstones and shales, and light-colored quartzites. On the whole, these strata seem to be more affected by the metamorphosing forces than any of those previously mentioned. They are in places highly altered; the shales are micaceous, and exhibit throughout a distinct bacillar structure. I have not observed any fossils in these beds in the Para valley itself, but Capt. Godwin Austen tells me that he found some carboniferous Spirifers a little farther to North-west; this would be very close to the point where our section is drawn.

CHAPTER VII.—*Metamorphic schists, &c.*

Entering the Tsomoriri valley we come upon quite a different geological horizon.

6.—Metamorphic rocks.

At the mouth of the valley itself we have to the west still the sandstones and quartzites, which can be referred to the Kuling series, but on the eastern side are distinctly metamorphic rocks. These latter are the only ones which become visible on both sides of the valley, and extend far to North. In the section the width of the band of metamorphic rocks, including the gneissose and granitoid beds, amounts to nearly

24 miles from south-west to north-east. The strike of all the rocks is, as previously stated, from north-west to south-east, and the dip is principally to south-west throughout.

Chloritic and mica schists.—The metamorphic strata next below the carboniferous rocks consist chiefly of thin-bedded chloritic and micaceous schists, traversed by a great number of veins of pure white quartz. A short range of snow-covered mountains, which rise to about 21,000 feet, extends some distance to the north-west and terminates somewhat to north of the southern end of the Tsomoriri lake. This range consists of granitoid gneiss, coarsely stratified, in fragments representing good typical granite. The rock is peculiar from having the greater quantity of felspar of a pink *Orthoclas*, which we met here only for the second time on all our journey. The felspar and quartz are present nearly in equal quantities, and the mica is a dark brown or black Biotite. I have not observed any veins of Albite-granite in this gneiss, neither any other accessory minerals worthy of particular attention. To the North of this granitoid ridge we have again a series of thinner stratified beds. They are principally quartzose schists, containing some felspar and laminated Biotite of a grey graphitic colour; Muscovite is very subordinate and often wanting altogether. Through the felspar these schists, when occurring in somewhat thicker beds, pass very easily into gneiss.

Gneiss.

Quartzose schists.

True gneiss is again to be found in the neighbourhood of the small Gyagar lake (to the north of Tsomoriri). It is apparently very different from the former, South of Korzok. The quartz is white but more impure and sandy, the mica is the same Biotite, and besides smaller pieces of pure Felspar, there occur large crystals of Orthoclas which are very impure by admixture of white Albite and Mica. Veins of Albite-granite have equally not been observed here, but black Tourmalin is to be met with in quantities and often in large lumps.

Being rather thinly stratified, the gneiss passes on the other side with very gradual changes again into quartzose beds, which are only devoid of the large crystals of felspar, but still contain schorl in abundance. These quartzose schists form both sides of the Puga valley and become towards the Epidote rocks somewhat chloritic, and even garnetiferous, they dip against these Epidote rocks, where they are visible in the eastern part of the Puga valley.

The axis of Cunningham's *Trans-Himalaya* or *Tsomoriri range* consists here of a series of *Epidote*, *Diallage* and *Serpentine* rocks. From their dark colours these rocks have sometimes been referred to *basalts*, but they have certainly nothing to do with these more recent volcanic rocks. At first coming to the camp on Puga stream we met with an epidote rock, consisting of crystallized or granular masses of *Epidote*, *Quartz* and *Albite*. The epidote when crystallized occurs in short prisms of yellowish or bright green colour.

Epidote rock.

It is often replaced by *Diallage* occurring in the same manner in short laminar prisms and forming a beautiful *Syenite-like* rock. Somewhat farther to North the Epidote disappears altogether, and the *Diallage* is often found disseminated through a dark green serpentine mass, and in this way forming a very peculiar rock which by many geologists, especially in the Apennines and Southern Alps, would be called *Gabbro*; the Himalayan agrees exactly with the Alpine rock. *Diallage* occurs besides in large lumps, and very seldom is any *Bronzite* to be seen here. The Serpentine rock contains also sometimes sparingly zeolitic and felspathic minerals, and varies greatly in colour. Farther to East it is occasionally to be found as Serpentine-schist and purer in thin veins. In the Puga valley itself no stratification whatever is perceptible in the whole series of these last-mentioned rocks; they have a truly massive structure.

Diallage rock.

Gabbro.

What is still remarkable and perhaps worthy of notice are large spheroidal masses of quartz, which, in addition to numerous quartz veins, occur throughout the Serpentine rock.

CHAPTER VIII.—*Sandstones and slates in the Indus Valley.*

Reddish and greenish slates and sandstones.

In the Indus valley itself the last described series of rocks is followed at first by reddish slates, and underlying these greenish sandstones and slates are visible farther on. These are the only rocks which are to be noticed all through the Indus valley along the northern border of Rupshu as far as Ronggo (properly spelt *rong*, narrow gorge, and *s'go* the door). At the mouth of the Puga stream the Indus flows in an anticlinal, the sandstones and slates dipping on the southern side to south-west, and on the northern slightly to north-east. The green and reddish sandstone have an immense thickness here, some of the hills on the northern side are seen rising 3,000 and 4,000 feet, and consisting apparently of these rocks only. It is impossible to imagine, even approximately, of what age these rocks may be, although they probably belong to a palæozoic series. No fossils whatever have been observed in them; neither during our survey, nor have I heard that anybody else has noticed any traces of organic remains in them. I have seen a few fragments of a white crystalline limestone, which has been brought from the Pangkong lakes by Capt. Godwin Austen, who informed me that the reddish and greenish rocks are there overlaid by limestone.

Age doubtful.

CHAPTER IX.—*River and Lacustrine deposits.*

River deposits.

During the previous remarks I have omitted to mention anything regarding the more recent deposits; there is however, very little to be said. In the Indus valley itself deposits, hardened sometimes to a compact conglomerate,

are to be observed several hundred feet above the present level of the river, and large alluvial plains exist in places on both sides, which must have been laid dry only at a recent period. There can be no question that the lake system in Rupshu was in former times, as noticed by Genl. A. Cunningham, a more extensive one, and that the waters have decreased constantly in their extent over the surface. Indeed they are constantly disappearing, and not only very considerably, but even very rapidly. There are but few glaciers in middle and northern Rupshu, and these nourish only a few streams, which do not become dry during the whole year. Most of them do so, but the few, which flow throughout the whole year, carry a great quantity of debris and sand into the stagnant water reservoirs; the lakes reduce their depth, cause the water to evaporate more quickly, and at the same time to become more brackish, unfit for animal life, and at last they disappear altogether and give rise to a large plain, covered with *Carices* and inhabited by Kyangs. Where this proceeding will terminate is quite clear, and the time cannot be very far distant when all the lakes will cease to exist. At present large plains of accumulated sand are attached to every lake, and show distinctly its previous larger extent. Some of the lakes have disappeared in the very recent period, and even in the last years. As one instance I need only recall the fact that in 1847, when Genl. A. Cunningham visited Rupshu, a portion of the Hanle lake was still in existence, and Genl. A. Cunningham says, that it was once the largest sheet of water in Ladak. When we spent a few days of the middle of August round Hanle last year not a trace of the Hanle-tso was visible, and the plain, although marshy, was richly covered with *Gramineæ* and *Carices*. With regard to a second question relating to the borax and sulphur of Puga, which I may probably be supposed to notice, it is scarcely necessary to add to what has been already and repeatedly communicated in the "Selections, etc., of the Punjab Administration, Lahore,

1855," Vol. II, No. XII. The borax occurs, as known, all through the middle portion of the Puga valley, and owes, no doubt, its existence to the numerous hot springs, some of which have a temperature very near the boiling point of water of the same locality (178° F.) Except these hot springs, the country has nothing in common with a volcanic district, which name Cunningham gives to it.

The sulphur is obtained from a few holes on the northern edge of the valley; it occurs with many other minerals, as *Alum, common Opal* and *Satin gypsum.* The sulphur is disseminated, chiefly in small crystals, through the decomposed quartz schist. The whole must have been formed and crystallized out evidently at a much higher temperature than at present exists.

The official of the Kashmir Maharajah informed us, that the greatest amount of Bórax which is carried away yearly, never exceeds 4,000 maunds, and that of Sulphur 500 maunds. This would be hardly as much as it was several years ago. The Government could not wisely do anything more than it has done, namely improve the road and leave that little trade in the hands of the boiparis, who are mostly inhabitants of Kulu.

PART III.—GENERAL REMARKS ON THE RELATIVE AGES OF THE DIFFERENT FORMATIONS.

After our detailed examination of each of the formations in the preceding pages, two important questions present themselves, to give a definite answer to which would be very desirable : 1*st.*—What is the geographical extent, and what is the geological connection of the different stratified groups on the Northern side of the Himalaya? And, 2*nd.*—Do these give any evidence bearing on the age of the stratified series which occur on the Southern side of the same mountain ranges?

We regret to say that as yet neither of these questions can be answered with full satisfaction; we shall briefly summarize in the following pages, what may be stated with a certain amount of confidence, on these points.

As regards that part of the first question which refers to the geographical extent of the several series, we have already had occasion to state, that only a small portion of the area to the North of the main geological axis has been as yet examined, the survey of the adjoining districts being still in progress. The districts lying to the North-west of the area examined, during last year will be visited during the present season (1865). All the portions of Bissahir and Ngari, which are adjacent on the South-east, will be examined subsequently. When this has been done, we shall be able to present a geological map of the country between the Pir-Panjal range and the Indus on the one hand, and between Skardo and South-western Ngari-Khorsum, on the other. It is equally certain that, only after such an examination, should we feel justified in discussing the geological development of the North-

western Himalaya, a point requiring very careful investigation owing to its intimate relationship to that of some European ranges of mountains. A knowledge of the geological structure of the Himalaya may, very probably, again raise questions on some theoretical views of mountains, and mountain-range theories, which have long attracted so much attention from many most able observers, and for the discussion of which materials have been carefully collected, in Europe and in America, for many years past.

The second part of our first question relates to the Geological, or the stratigraphical connection of the several groups. To answer this, it may be well to give here a short review of what has been already stated in greater detail.

Looking at the continued sections of that portion of the North-western Himalayas, to which we have specially referred, it would seem to be formed of five different zones of rocks, parallel to each other, and with their main strike from North-west to South-east. As already pointed out by Genl. Cunningham, not one of these geological zones is *essentially* connected with the Geographical or orographical ranges. Whether it may be possible, after further investigation, to trace out any connection of this kind is still an interesting question.

I.—The first zone, geologically speaking, extends, I believe, from near the plains of India to the Central Gneiss; and has a breadth of about 84 miles, in a direction from South-west to North-east. Scarcely more than one-third of the entire breadth is composed of un-metamorphic, or at least of not highly metamorphic stratified rocks, comprising those groups of which Mr. Medlicott treats, with much detail, in his paper already more than once referred to. The Sivalik, Nahun and Subathoo groups belong to the Tertiary period; the age of the Krol, Infra-Krol, Blini, and Infra-Blini groups is not yet defined. These groups contain locally some truly metamorphic strata, but the greater part of these latter extends further to the

North, and consists of micaceous, chloritic, and gneissose schists and thin-bedded gneiss. Quartzose rocks are very common through all the series.

II.—The second zone is to be regarded as the principal Geological axis of the North-west Himalaya. It consists chiefly of a porphyritic gneiss (with Biotite) coarsely stratified, and traversed by veins of porphyritic Albite-granite. The breadth of this zone is about 14 miles. South of the Pin valley this central gneiss forms only the Southern branches of the Pir-Panjal range. To the South-east it seems to unite with this main range, while in its North-western extension it (the gneiss) crosses the same range, joining with the Baralatse range, North of Lahoul.

III.—The third zone comprises the rocks lying to the North of the Central Gneiss, its breadth being about 55 miles. The rocks of this zone are only very slightly, or locally, altered by metamorphosing agencies. They represent European formations belonging to the Palæozoic, Mesozoic, and Tertiary periods. The greatest elevations in the North-western Himalaya lie within this zone, the rocks of which form a kind of basin extending from the North-west to the South-east along the northern ranges of the Himalaya. Whether these basins have been originally connected, and separated after the lapse of geological periods, or whether the different formations have been deposited in already isolated areas, is a question the solution of which can only be looked for from subsequent researches.

The centre of that portion of the basin which we have described lies in Spiti, and is indicated on the little map (Pl. I) by the extent of the Spiti shales, which are of oolitic age. To the North and South of the jurassic ellipse we have, therefore, a repetition, more or less, of the same formations; of which we have recorded the following,

1. *Bhabeh series*, probably *Lower Silurian*, consisting of sandstones, slates, and quartzites, with species of *Orthis* and *Chætetes yak*, Salter.

2. *Muth series*, probably of Silurian age also, and consisting of three different groups of rocks, the lowest of which are purple quartzites, the middle arenaceous limestones, and the upper white quartzites. In the middle series *Orthis*, *Strophomenæ* and *Tentaculites* have been observed.

Both these series are not to be traced in Rupshu, unless they have their equivalents in the fourth zone, the metamorphic rocks.

3. *Kuling series*, consisting of white quartzites, shales, limestones and sandstones, characterized as carboniferous rocks by the abundance of *Productus semireticulatus*, *Spirifer Keilhavii* and *Moosakhailensis*, etc. The strata of this series can be traced through all Spiti and Southern Rupshu, towards the middle of the basin, in dome-form upheavements. The thickness is not considerable.

4. *Lilang series*, representing the *Upper Trias* (the Hallstadt and St. Cassian beds) by dark colored limestones and calcareous slates and shales. This series rests immediately above the carboniferous beds, and we have, therefore, the whole Permian (Dyas) and lower Trias (Muschelkalk and Bunter Sandstein) wanting in this part of the Himalayas. Their existence is not yet proved even in any other districts of these mountains.

As characteristic fossils may be quoted *Ammonites subumbilicatus*, *Ausseanus*, *fissicostatus*, *floridus* and *Studeri*, *Hallobia Lomeli*, *Athyris Strohmeyeri*, and *Deslongchampsi*. Considerable disturbances took place after the Trias.

5. *Para limestone*, black dolomitic, strongly bituminous and often earthy limestones, containing *Megalodon triqueter* and *Dicerocardium Himalayense* (n. sp.) I have restricted these beds, being quite different, mineralogically, stratigraphically, and palæontologically, from the previous, under the name Rhætic-formation, and would exclude the *Avicula contorta* beds. It need hardly be remarked, that the beds with *Megalodon triqueter* form in the Alps a most prominent

feature, and that they ought to be separated under a special name, as proposed by Gümbel and supported by Suess. A denomination, abstracted from the mineralogical character of the rock, may be locally of great service, but it cannot be universally accepted. And what advantage is gained by the compound names of *Upper Trias, Muschelkeuper, Oberkeuper, etc.*, if we have not got the proper equivalents of the strata with *Megalodon triqueter* in any of these formations ?

The Para limestone is chiefly developed on the northern side of the basin, and seems to be wanting on the southern side. It thins out already in the northern parts of Spiti. This seems to correspond very well with the great dislocations which, after the depositions of the Trias, seem to have taken place over extensive areas.

6. *Lower Tagling limestone*, a dark brown or black, often oolitic and bituminous, limestone. It rests on the southern side above the *Trias*, on the northern above the *Rhætic*, and extends over the greater part of Spiti and Southern Rupshu, in more or less horizontal strata towards the tops of hills and ranges. Its entire thickness is above one thousand feet.

The characteristic fossils are *Ammonites Germani*, D'Orb. (?) *Belemnites bisulcatus, tibeticus*, and *Budhaicus* (n. sp.) *Avicula inæquivalvis, Pecten Valoniensis, Terebratula gregaria, pyriformis* and *punctata, Waldheimia Schafhœutli, Rhynchonella variabilis, Austriaca, fissicostata*, etc. Most of these fossils are known to characterize the *Kossen* strata, which are often quoted as belonging to the Rhætic formation.

The '*Kossner-schichten*', or the beds with *Avicula contorta*, attracted special attention long since in the Alps, and have been traced since through all Europe. The later researches and even those of the last year, some of which I am sorry to say I have not yet had an opportunity of studying in detail, show that the questions relating to the

so-called 'Kossner-schichten' are far from being settled. The stratigraphical position is in most cases determined, but the difference of opinion is as to the series to which they ought to be assigned, or whether they ought not to be kept as a distinct formation altogether under a separate name. The general result, up to the present time, is that the Italian and French Geologists are chiefly in favor of referring the beds in question to the Lias, and the North Alpine Geologists are more of opinion that they have a stronger relation to the Trias. The separation under a special denomination is generally regarded as unnecessary.

I cannot entirely agree with the views of those Geologists who have devoted years to the study of the North Alpine formations And it may be of interest to state the results, which I deduce from my Himalayan Survey. The beds with *Megalodon triqueter* rest on the Upper Trias ("Hallstadter Schichten"), and seem to form a distint series to which the name *Rhætic* may probably be well restricted.

The beds with the Brachiopoda of the 'Kossner-schichten', contain, (besides the characteristic species of *Terebratula* and *Rhynchonella*) *Belemnites* and *Ammonites* of lower liassic character, and some other species identical with lower liassic fossils, as already mentioned. There is certainly no accidental mixture of those fossils which I have quoted from these lower beds. I am, therefore, inclined to the opinion of the French and Italian Geologists, that the *Avicula contorta* beds represent the lower lias. Stoppani says, that those strata of the so-called Dachstein-Kalk which rest above the Kossner-schichten do not contain *Megalodon triqueter* (M. Gümbelii !) but a liassic *Conchodon.* Although I have myself seen these strata at several places, I would not entirely trust to my own observations. The question will doubtless be settled with all needful care by our Alpine friends. In any case there seems to exist a good deal of local difference among these strata

7. *Upper Tagling limestone.* This is a dark earthy and bituminous limestone, which may be taken to represent the " Hierlatz-schichten" of the Alpine formations. I have met it only along the top of the Baralatse-range to the North of Spiti, forming the boundary towards Rupshu. To the South of the basin these beds are certainly wanting, at least locally. It is very difficult to trace mineralogically theboundary between the lower and upper Tagling limestone, although the beds with the characteristic fossils of the upper series are perfectly different. I have to mention particularly *Chemnitzia undulata, Trochus epulus, latilabrus, Terebratula Sinemuriensis.*

When I wrote the monograph on the *Gastropoda* and *Acephala* of the Hierlatz strata in 1861, I expressed the opinion, that these strata corresponded with those of the *middle Lias* of Normandy. Prof. Oppel subsequently urged the view that the ' Hierlatz-schichten' represented the lower and not the middle Lias (Bronn's Jahrb. 1862), and even threw doubt on some of my identifications of the fossils. I did not reply at that time to Prof. Oppel's opinion, because I thought it merely a trifling matter, and it was evident from my paper, that I declared the " Hierlatz-schichten " to be middle Lias only on the ground of identity of some fossils with others from Normandy, where the representative strata are believed to be of middle liassic age. Of those supposed identical fossils, which I quoted in my paper, I fully think still, as I did then, and would not recall even a single one; on the contrary I would rather increase their number. Having treated the previous group as *lower Lias,* I must of course still persist in my previously expressed opinion, that the *Hierlatz-schichten* of the Alps, or the *Upper Tagling limestone* of the Himalayas represent the *Middle Lias.*

8. *Jurassic earthy slates,* with Belemnites and a species of Posidonomya very like *Pos. Am. ornati* have been noticed South of Gieumal above the lower Tagling limestone. They seem to be only very

locally developed, and may prove to be only a local alteration of the next series.

9. *Spiti shales.* A black crumbling rock full of calcareous concretions. Its extent is limited, with the following secondary formations to Spiti only, and is indicated on our sketch map (Plate I). The characteristic fossils are *Am. macrocephalus, Parkinsoni, curvicosta, liparus, triplicatus,* and *biplex, Astarte major* and *unilateralis, Nucula cuneiformis, Trigonia costata,* etc.

Without entering at present on the questions of separate zones, I believe the best equivalent of these beds is Quenstedt's *Brown Jura,* or now usually called *Dogger,* comprising a great number of so-called formations, clays, limestones, sandstones, shales, etc., which have in England, France, Germany, etc., only local value. The Himalayan Jura approaches in many respects in the character of its fossils to the Russian. It is a mistaken opinion to regard certain beds, which contain *Planulati-Ammonites* as *upper Jura.* The Spiti shales have been treated in this manner, because they abound in " Planulati." But all those we do find *Am. curvicosta, Braikenridgii, triplicatus* and the Kimmeridgien form of *Am. biplex, all* these species are not upper but middle jurassic; even if we could abstract all the rest of the fossils. *Trigonia costata* proves nothing, as it goes through many strata without essential alteration, similarly the *Avicula inæquivalvis.* The Cutch deposits are equally not of *upper* but of *middle jurassic* age, and have a great number of species identical with the *oolite inferieur* of *Bayeux* and *Montreuil Belly.*

10. *Gieumal sandstone;* yellowish or white quartzitic and calcareous sandstones characterized by the occurrence of *Opis, Anatina, Avicula echinata* and *Amusium demissum.* From their stratigraphical position I believe these strata to represent the upper Jura or *Malm;* the fossils found do not afford quite satisfactory evidence.

11. *Chikkim limestone,* by its white or bluish colour very much recalling the *Rudisten limestones* of the Alps, and being an equivalent

of one or the other of those beds. From the character of the Foraminifera and the fragments of Rudistes they probably correspond best with the middle series of these limestones. There seems to be no Neocomian developed.

12. *Chikkim shales* form the uppermost, probably secondary, strata and seem to be closely connected with the previous limestones. No fossils have been traced in them.

13. *Karéwah deposits.* The extensive river and lacustrine accumulations of debris, conglomerate and deposits of clays and sand, have been so called. They are of very great thickness, to be observed nearly along all the principal rivers, and are no doubt, equally as those in the Alps, of different ages. But scarcely any of them will, I believe, be proved to be of real marine origin, as these parts of the country must have been at this time already very highly elevated above the level of the sea.

IV. The fourth zone occupies middle and northern Rupshu. It extends from the termination of the Tsomoriri in the Para valley to a little beyond Puga, a distance of about 35 miles. The chief rock is a quartzose and micaceous schist, with a few interruptions from granitoid gneiss. There is black Tourmalin present, but no veins of Albite granite are to be observed, and the gneiss does not seem to have caused any particular dislocations or disturbances in the metamorphic series. To the North of this zone I have previously remarked the *Epidote, Diallage* and *Serpentine rocks,* the latter of which contain often *Chromic iron.* The last strata which have been noticed, and which represent the next or *fifth zone,* are *slates and sandstones* of doubtful age, but probably very old.

We come now to our second question, whether the examination of the rocks on the northern side of the Himalayas has afforded any materials, from which the age of the strata on the southern declivities can be traced. I shall restrict my remarks to the Simla section only.

Referring to Mr. Medlicott's section (Mem. III. part. 2, p. 32) from below Simla to Hatu near Narkanda, we leave, proceeding to South, the metamorphic strata a few miles South* of Muttiani. The metamorphic strata I would identify with the lower and middle beds of the *Bhabeh series.* The Infra-Blini sandstones and Simla slates, which extend from South of Muttiani to Simla, I think represent the greenish sandstones and slates of the upper beds of the *Bhabeh series.*

The *Blini conglomerate* and purple sandstone is mineralogically nearly identical with the lowest beds of the Muth series; the *Blini limestone* seems to be represented to the North by the arenaceous limestone of the middle beds; and the upper quartzite of the *Muth series* by a small thickness of a whitish, quartzose schist, which is to be seen above the *Blini limestone* all round Simla. The *quartzose beds* on the Boileaugunj hill and the *Garnetiferous mica-schist* on Jako may have their representatives in the *Kuling or Carboniferous series.*

For the *Infra-Krol* beds, on the Krol mountain itself, I have nothing to compare with on the North of the Himalayas, but I would not like to identify them with the beds on Jako at Simla. When I first saw the Infra-Krol beds near Masuri in 1863, I believed them to be mineralogically so very identical with the "Bunter Sandstein" of the lower Trias, that I felt very much distressed not to find a *Posidonomya Claræ* or *Myacites fassaensis.* I have not been able to find any support for this opinion, neither was my impression during the visit of last year different from that previously produced.

The *Krol limestone,* especially those characteristically oolitic beds of black limestone, I would incline very much to identify with the similar limestones at Muth, belonging to our *Lilang series,* and representing the Alpine *upper Trias.* But there is here equally no palæontological

* At the point where, on Mr. Medlicott's section, an indication is given of closer striation.

support whatever, and until fossils have been found at least in one or the other of the southern Himalayan rocks nothing else can give full satisfaction. The Tertiary rocks are not represented, in that portion of the Northern Himalayas which has been examined last year, but they are known to exist farther to North-West. Should the foregoing identification prove only approximately to be correct, it is strange to think we have all the liassic, jurassic and cretaceous strata wanting on this side of the Himalayas, and still they are known to exist, at least partially, in the Punjab and further to the South in Cutch. Large is still the field for geologists in India!

TABULAR LISTS

of the Fossils described in the preceding pages, shewing their distribution in the several formations, together with references to page and plate of the descriptions.

Genera and Species.	Description and Figure in this Paper.		Muth Series. Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
PLANTÆ.												
Sphæro-coccites, (?) ...	....	22	*	..	..	..	..	..	..	..	..	..
FORAMINIFERA.												
Cristellaria, *sp.*	....	118	..	..	..	..	..	..	..	..	..	*
Dentalina, *sp.*	....	118	..	..	..	..	..	..	..	..	..	*
Globulina, *sp.* (?)	....	30	..	..	*	..	..	..	..	..	..	..
Haplophragmium, *conf.* irregulare, *Reuss.*	....	118	..	..	..	..	..	..	..	..	..	*
Quinqueloculina, (?) ...	....	30	..	..	*	..	..	..	..	..	..	..
Rotalia, *sp.*	....	118	..	..	..	..	..	..	..	..	..	*
Textilaria, *sp. sp.*	....	118	..	..	..	..	..	..	..	..	..	*
POLYPARIA.												
Chætetes Yak, *Salter*, ...	....	21	*	..	..	..	..	..	..	..	..	..
Cyathophyllum, *sp. sp.* ...	....	22	*	..	..	..	..	..	..	..	..	..
Lithodendron, (?)	....	..	..	..	*	*	..	..	..	..	..	..
Syringopora, *sp.*	....	22	*	..	..	..	..	..	..	..	..	..
ECHINODERMATA.												
Crinoid stems	....	19 37	*	*	*	..	..	..	..	..	..	..
Encrinus Cassianus, (?) *Laube*, ...	....	37	..	..	*	..	..	..	..	..	..	..
Salenia (?)	....	86	..	..	..	..	..	..	..	*	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
BRACHIOPODA.												
Athyris Deslongchampsi, *Suess*, ...	....	43	..	..	*	..	..	..	..	..	..	..
Athyris Strohmeyeri, *Suess*,	....	43	..	..	*	..	..	..	..	..	.	..
Orthis, *conf.* compta, *Salter*,	....	23	*	..	..	..	..	..	..	..	..	..
„ *conf.* resupinata, *Phill.*	....	23	*	..	..	..	..	..	..	..	..	..
„ *conf.* thakil, *Salter*,												
„ *var* α convexa, *Salter*,	....	23	*	..	..	..	..	..	..	..	..	..
„ „ δ striato-costata, *Salter*, ...	....	23	*	..	..	..	..	..	..	..	..	..
„ *conf.* tibetica, *Salter*,	.. .	23	*	..	..	..	..	..	..	..	..	..
Productus longispinus, *Sow.*	....	29	..	*	..	..	..	..	..	..	..	..
„ Purdoni, *Dav.*,	....	29	..	*	..	..	..	..	..	..	..	..
„ semi-reticulatus, *Martin*, ...	....	29	..	*	..	..	..	..	..	..	..	..
Rhynchonella Austriaca, *Suess*, ...	....	71	..	..	..	..	*	..	..	..	..	..
„ fissicostata, *Suess*, ...	....	70	..	..	..	..	*	..	..	..	..	..
„ mutabilis, *Stol.* ...	III. 6-9	40	..	..	*	..	..	..	..	..	.	..
„ obtusifrons, *Suess*, ...	....	70	..	..	..	..	*	..	..	..	..	..
„ pedata, *Bronn.*	....	70	..	..	..	..	*	..	..	..	..	..
„ retrocita, *Suess*,												
„ *var*, angusta, *Stol.* ...	III. 13	42	..	..	*	..	..	..	..	..	..	..
„ ringens, *Herault*, ...	....	71	..	..	..	..	*	..	..	..	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Giumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Brachiopoda.—(*Cd.*)												
Rhynchonella Salteriana, *Stol.*	III. 11-12	41	..	..	*	..	..	..	..	..	..	..
„ Theobaldiana, *Stol.*... ...	III. 10	41	..	.	*	..	..	..	..	..	..	..
„ variabilis, *Schloth.* ...	....	71	..	..	..	..	*	..	..	..	..	..
„ varians, *Sow*	....	87	..	..	..	..	..	..	..	*	..	..
Spirifer altivagus, *Stol.* ...	III. 3	28	.	*	..	..	..	..	..	..	..	..
„ *conf.* fragilis, *Schloth.*	....	38	..	..	*	..	..	..	..	..	..	..
„ Keilhavii, *Buch.* = *S. Rajah*, Salter ...	....	27	..	*	..	..	..	..	..	..	..	..
„ Lilangensis, *Stol.*...	III. 4	38	..	..	*	..	..	..	..	..	..	..
„ Moosakhailensis, *Dav.*	....	27	..	*	..	..	..	..	..	..	..	..
„ *Rajah*, *Salter*, vid. S. Keilhavii, ...												
„ *sp. nov.*	....	37	..	..	*	..	..	..	..	..	..	..
„ Spitiensis, *Stol.* ...	III. 5	39	..	..	*	..	..	..	..	..	..	..
„ Stracheyi, *Salt.* ...	....	38	..	..	*	..	..	..	..	..	..	..
„ Tibeticus, *Stol.* ...	III. 1-2	28	..	*	..	..	..	..	..	..	..	..
Strophomena *conf.* halo, *Salt.*	....	23	*	..	..	..	..	..	..	..	..	..
Terebratula gregaria, *Suess.*	....	68	..	..	..	..	*	..	..	..	..	..
„ punctata, *Sow.*	....	68	..	..	..	..	*	..	..	..	..	..
„ pyriformis, *Suess.* ...	....	68	..	..	..	..	*	..	..	..	..	..
„ Schaffhæutli, *Stopp.* = *T. Cornuta*, *Sow.*	....	69	..	..	..	..	*	..	..	..	..	..
Sinemuriensis, *Opp.*	....	80	..	..	..	..	..	*	..	..	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kaling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Brachiopoda.—(*Cd.*)												
Terebratula *Sp.*	....	87	..	..	..	..	..	..	..	*	..	..
Waldheimia Stoppanii, *Suess.*	....	44	..	..	*	..	..	..	..	..	..	..
RUDISTA.												
Fragments of	....	117	..	..	..	..	.	..	..	..	..	*
PELECYPODA.												
Amusium demissum, *Bean.* sp. (*Pecten* id.) ...	....	115	..	..	..	..	..	..	..	..	*	..
„ *conf.* solidum, *Trautsch.* ...	....	87	..	..	..	..	..	..	.	*	..	..
„ *sp.*	....	72	..	..	..	..	*	..	.	..	..	..
Anatina Spitiensis, *Stol.* ...	X. 4	115	..	..	..	..	..	..	..	..	*	..
„ *sp.*...	....	116	..	..	..	..	..	..	..	..	*	..
Arca, (*vide* Macrodon) ...												
„ „ Lycetti, *Moore.*	....	76	..	..	..	..	*	..	..	..	..	..
Astarte hiemalis, *Stol.* ...	IX. 2, 3	91	..	..	..	..	..	..	..	*	..	..
„ major, *Sow.* ...	....	91	..	..	..	..	..	..	..	*	..	..
„ Spitiensis, *Stol.* ...	IX. 9	91	..	..	..	..	..	..	..	*	..	..
„ unilateralis, *Sow.* ...	....	90	..	..	..	..	..	..	..	*	..	..
Aucella Blanfordiana, *Stol.*	....	88	..	..	..	..	..	..	..	*	..	..
„ leguminosa, *Stol.*...	VIII. 8	88	..	..	..	..	..	..	..	*	..	..
Avicula echinata, *Sow.* ...	....	114	..	..	..	..	..	.	..	..	*	..
„ inequivalvis, *Sow.*	....	75	..	..	..	..	*	..	..	..	..	..
„ punctata, *Stol.* ...	VI. 2	76	..	.	..	..	*	..	..	..	..	..
„ *sp.*	....	29	..	*	..	..	..	..	..	..	..	..
Aviculo-pecten, *sp.* ...	....	29	..	*	..	..	..	..	..	..	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Pelecypoda.—(*Continued.*)												
Cardiomorpha, *sp.*	....	29	..	*	..	..	..	..	..	..	..	..
Cyprina trigonalis, *Blanf.*	....	90	..	..	..	.	..	..	..	*	..	..
Dicerocardium Himalayense, *Stol.*	VII.	63	..	..	..	*	..	..	..	..	..	..
Gervillia, *sp.*	....	76	..	..	..	..	*	..	..	..	..	..
Gryphæa, *sp.*	....	114	..	..	..	..	..	..	..	..	*	..
Halobia Lommeli, *Wissm.*	....	44	..	..	*	..	..	..	..	..	..	..
Homomya Tibetica, *Stol.* ...	IX. 4	92	..	..	..	..	..	..	..	*	..	..
Inoceramus Hookeri, *Salt.*	....	89	..	..	..	..	..	..	..	*	..	..
Lima, *conf.* Ramsaueri, *Hörnes,*	....	45	..	..	*	..	.	..	.	..	..	..
„ densicosta, *Quenst.*	....	75	..	..	..	..	*	..	.	..	..	..
„ *n. sp.* (*like* scrobiculata, *Stol.*)	....	45	..	..	*	..	..	..	..	..	..	..
„ *n. sp.*	....	45	..	..	*	..	..	..	..	..	..	..
„ *sp.* (*like* rigida, *Desh.*)	....	89	..	..	..	..	..	..	..	*	..	..
„ *sp.*	....	115	..	..	..	..	..	..	..	..	*	..
Macrodon Egertonianum, *Stol.*	VIII. 7	89	..	..	..	..	..	..	..	*	..	..
Megalodon triqueter, *Wulf.*	....	64	..	..	..	*	..	..	..	..	..	..
Modiola, *sp.*...	....	81	..	..	..	..	..	*	..	..	..	..
Myoconcha Lombardica, *Hauer,*	....	45	..	..	*	..	..	..	..	..	..	..
Mytilus mityloides, *Blanf.*	....	115	..	.	..	..	..	..	..	..	*	..
Neoschizodus, *sp.*	....	62	..	.	..	*	..	..	..	..	..	..
Nucula cuneiformis, *Sow.*...	....	90	..	..	..	..	..	..	..	*	..	.
„ *sp.*	....	90	..	..	..	..	..	..	..	*	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Tara limestone, Rhætic.	Low Tagling limestone, Low Lias.	Up Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Pelecypoda.—(*Continued.*)												
Opis, *sp.*	....	116	..	..	..	..	..	..	..	..	*	..
Ostrea *conf.* acuminata, *Sow.*	....	72	..	..	..	..	*	..	..	..	..	.
„ *conf.* anomala, *Terquem*, ...	....	72	..	..	..	..	*	..	..	..	..	..
„ flabelloides, (?) *Lam.*	....	87	..	..	..	..	.	..	..	*	..	..
„ gregaria, *Sow.* (?)...	....	114	..	..	..	..	..	..	..	..	*	..
Pecten (in part) *see Amusium*												
„ bifrons, *Salt.* (partim)	....	74	..	..	..	..	*	..		..	..	..
„ „ „ „ ...	....	115	..	..	..	..	..	..	..	..	*	..
„ *conf.* palosus, *Stol.*...	....	73	..	..	..	..	*	..	..	..	..	..
„ lens, *Sow.*	....	87	..	..	..	..	..	..	..	*	..	..
„ monilifer, *Sow.* ...	....	73	..	..	..	..	*(?)	..	..	..	..	..
„ sabal, *Salt.*... ...	....	73	..	..	..	..	*	..		..	..	..
„ Valoniensis, *Defr.*...	....	75	..	..	..	..	*	..	..	..	..	..
Posidonomya Ornati, *Quenst.*	....	84	..	..	..	..	..	..	*	..	..	..
Trigonia costata, *Park.* ...	....	90	..	..	..	..	..	..	..	*	..	..
GASTROPODA.												
Actæonina *conf.* cincta, *Goldf.*	....	82	..	..	..	..	..	*	..	..	..	..
Chemnitzia *conf.* coarctata, *Desh.* ..	....	77	..	..	..	..	*	..	..	..	..	..
„ *conf.* Phidias, *D'Orb.* ...	....	77	..	..	..	..	*	..	..	..	..	..
„ undulata, *Reuss*,	....	81	..	..	..	..	..	*	..	..	..	..
Dentalium *conf.* giganteum, *Phill.*	....	76	..	..	..	..	*	..	..	..	..	..
Discohelix, *sp.*	....	46	..	..	*	..	..	..	..	..	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Gastropoda.—(*Continued.*)												
Encyclus, *sp.*	....	82	..	..	..	..	..	*	..	..	..	..
Natica, *conf.* pelops, *D'Orb.*	....	77	..	..	..	..	*	..	..	..	..	..
Nerinea, sp., *conf.* N. Goodhallii, *Sow.*	....	77 82	..	..	..	..	*	*	..	..	..	..
Nerita, *sp. nov.*	....	76	..	..	..	..	*	..	..	..	..	..
Neritopsis *conf.* elegantissima, *Hörnes*	....	81	..	..	..	.	..	*	..	..	..	..
Pleurotomaria *conf.* Buchi,	....	46	..	..	*	..	..	..	..	..	..	..
„ *sp. sp.* ...	....	92	..	..	..	..	..	..	..	*	..	..
„ sterilis, *Stol.*	IV. 1	46	..	..	*	..	..	..	..	..	..	..
Trochus attenuatus, *Stol.* ...	....	82	..	..	..	..	..	*	..	..	..	..
„ epulus, *D'Orb.* ...	...	82	..	..	..	..	..	*	..	..	..	..
„ latilabrus, *Stol.* ...	....	81	..	..	..	..	..	*	..	..	..	..
CEPHALOPODA.												
Ammonites acucinctus, *Strach.* ...	....	92	..	..	..	..	..	..	..	*	..	..
„ *Adolphi*, Opp. = acucinctus...												
„ alatus, *Strach.*	....	110	..	..	..	..	..	..	..	*	..	..
„ Ausseanus, *Hauer*, ...	....	53	..	..	*	..	..	..	..	..	..	..
„ Batteni, *Strach.*	V. 2: VI. 1	59	..	..	*	..	..	..	..	..	..	..
„ biplex, *Sow.* ...	....	109	..	..	..	..	..	..	..	*	..	..
„ *Blanfordi*, Salter, = thuillieri, *Opp.*												
„ Braikenridgii, *Sow.*	....	106	..	..	..	..	..	..	..	*	..	..
„ *Cautleyi*, Opp. = Spitiensis ...												

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Cephalopoda.—(*Contd.*)												
Ammonites *circumspinosus*, Opp. = *inflatus macrocephalus*, Quenst. ...												
= liparus, Opp.	....	107	..	..	..	..	..	..	..	*	..	..
„ curvicosta, *Opp.*	....	105	..	..	..	..	..	..	..	*	..	..
„ difissus, *Hauer*,	V. 4	53	..	..	*	..	..	..	.	..	..	..
„ floridus, *Wulf.*	....	51	..	..	*	..	..	..	..	..	..	..
„ *funatus*, Opp. = triplicatus, *Sow.*												
„ Gaytani, *Klipst.*	....	53	..	..	*	..	..	..	..	..	..	..
„ Gerardi, *Blanf.*	....	54	..	..	*	..	..	..	..	..	..	..
„ *conf.* Germanii, *D'Orb.* ...	...	77	..	..	..	..	*	..	..	..	..	..
„ *Griffithii*, Strach = Theodorii, *Opp.*... ...												
„ *Groteanus*, Opp. = Spitiensis, *Blanf.* ...												
„ *Hookeri*, Strach. = octagonus, *Strach.* ...												
„ Hyphasis, *Blanf.*	X. 2	97	..	..	..	..	..	..	..	*	..	..
„ *interruptus*, Ziet = Germanii, *Opp.*												
„ Jollyanus, *Opp.*	....	51	..	..	*	..	..	..	..	..	..	..
„ *Jubar*, Strach. = Sabineanus, *Opp.* ...												
„ Khanikofi, *Opp.*	....	52	..	..	*	..	..	..	..	..	..	..

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Giumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Cephalopoda.—(*Contd.*)												
Ammonites *Kimmeridiensis*, Seebach, = biplex, *Sow.*						•						
,, liparus, Opp....	....	107	..	..	..	..	..	.	.	*	..	..
,, *Leymanni*, Opp. = acucinctus, *Strach.*												
,, Malletianus, *Stol.*	V. 1	58	..	..	*	..	..	..	..	..	..	..
,, Medleyanus, *Stol.*	IV. 5	54	..	..	*	..	..	..	..	..	..	..
,, macrocephalus, *Schlot.* ...	....	95	..	..	..	..	..	..	..	*	..	..
,, *conf.* macrocephalus, *Schlot.*	....	83 78	.	..	..	..	*	*		..	..	..
,, *Moerikeanus*, Opp. = Parkinsoni, *Sow.*												
,, *Nepalensis*, Gray = macrocephalus, *Schlot.*												
,, nivalis, *Stol.* ...	X. 1	106	..	..	..	..	..	..	..	*	..	..
,, octagonus, *Strach.* ...	...	96	..	..	..	..	..	..	..	*	..	..
,, Parkinsoni, *Sow.*	....	98	..	..	..	..	..	..		*	..	..
,, *Pichleri*, Opp. = acucinctus, *Strach.* ...												
,, Sabineanus, *Opp.*	.. .	101	..	..	..		..	..	..	*	..	..
,, *scriptus*, Blanf. = Spitiensis, *Blanf.*												

Genera and Species.	Description and Figure in this Paper.		Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Low. Lias.	Up. Tagling limestone, Mid. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
	Plate. Figure.	Page.										
Cephalopoda.—(*Contd.*)												
Ammonites *Seideli*, Opp. = Hyphasis, *Blanf.*												
„ *Sœmeringii*, Opp. = octagonus, *Strach.*	•											
„ Spitiensis, *Blanf.*	...	102	..	..	..	..	..	..	..	*	..	..
„ *Stanleyi*, Opp. = *scriptus*, Blanf. = Spitiensis, *Blanf.*												
„ strigilis, *Blanf.*	....	95	..	..	..	..	..	..	..	*	..	..
„ Studeri, *Hauer*,	....	55	..	..	*	..	..	..	..	..	..	..
„ *substriatus*, Opp. = ? acucinctus, *Strach.*												
„ *tenuistriatus*, Gray = Sabineanus, *Opp.*												
„ Theodorii, *Opp.*	IX. 5	99	..	..	..	..	..	..		*	..	..
„ Thuillieri, *Opp.*	....	56	..	..	*	..	..	..	..		..	..
„ *torquatus*, Blanf. = Braikenridgii, *Sow.*												
„ triplicatus, *Sow.*	....	108	..	..	..	..	..	..	..	..	..	..
„ *umbo*, Strach. = *Voiti*, Oppel, = Hyphasis, *Blanf.*												
„ *Wallichii*, Gray, = Parkinsoni, *Sow.*												
Anisoceras Gerardianum, *Stol.*	X. 3	110	..	..	..	..	..	..	..	*	..	..

Genera and Species.	Description and Figure in this Paper. Plate. Figure.	Page.	Muth Series, Silurian (?)	Kuling Series, Carboniferous.	Lilang Series, Trias.	Para limestone, Rhætic.	Low. Tagling limestone, Mid. Lias.	Up. Tagling limestone, Low. Lias.	Jurassic Slates.	Spiti Shales, 'Dogger.'	Gieumal Sandstone, 'Malm.'	Chikkim limestone, Cretaceous.
Cephalopoda.—(*Contd.*)												
Belemnites bisulcatus, *Stol.*	VIII. 1-4	78	..	..	..	..	*	..	..	..	..	..
„ Budhaicus, *Stol.*	VI. 3-6	78	..	..	..	..	*	..	..	..	..	..
„ canaliculatus, *Schlot.*	....	111	..	..	..	..	..	..	..	*	..	..
„ clavatus, *Blainv.*	....	112	..	..	..	..	..	..	..	*(?)	..	..
„ *sp.* (?)	....	83	..	..	..	..	..	*	..	..	..	..
„ *sp.* (?)	....	84	..	..	..	..	..	..	*	..	..	..
„ Tibeticus, *Stol.*	VIII. 5-6	79	..	..	..	..	*	..	..	..	..	..
Clydonites Hauerinus, *Stol.*	IV. 3	50	..	..	*	..	..	..	..	..	..	..
„ Oldhamianus, *Stol.*	IV. 4	50	..	..	*	..	..	..	..	..	..	..
Nautilus Spitiensis, *Stol.* ...	IV. 2	49	..	..	*	..	..	..	..	..	..	..
Orthoceras dubium, *Hauer*,	....	48	..	..	*	..	..	..	..	..	..	..
„ latiseptum, *Hauer*, ...	....	48	..	..	*	..	..	..	..	..	..	..
„ salinarium, *Bronn*.... ...	....	48	..	..	*	..	..	..	..	..	..	..
„ *sp.*	....	48	..	..	*	..	..	..	..	..	..	..
„ *sp.*	....	29	..	*	..	..	..	..	..	..	..	..
ANNELIDA.												
Tentaculites, *sp.*	....	23	*	..	.	..	..	..	..	..	..	..
VERTEBRATA.												
Fish remains	....	61	..	..	*	..	..	..	..	..	..	..

GENERAL SUMMARY.

	Silurian.	Carboniferous.	Triassic.	Rhætic.	Liassic, Lower.	Liassic, Middle.	Jurassic.	Jurassic, 'Dogger.'	Jurassic, 'Malm.'	Cretaceous.
Plantæ	1	..	..	..	..	..	..	..	..	..
Foraminifera ...	..	..	2	..	..	..	..	..	..	..
Polyparia... ...	3	..	1	1	..	..	..	..	..	..
Echinodermata ...	1	1	1	1	..	..	..	1	..	..
Brachiopoda ...	6	7	11	..	10	1	..	2	..	..
Rudista	..	..	..	..	..	..	..	..	..	*
Pelecypoda ...	..	3	4	3	14	2	1	17	8	..
Gastropoda ...	..	..	3	..	6	7	..	1	..	..
Cephalopoda ...	..	..	18	..	5	1	1	18	..	..
Annelida	1	..	..	..	..	..	..	..	..	..
Total ...	12	11	40	5	35	11	2	39	8	1

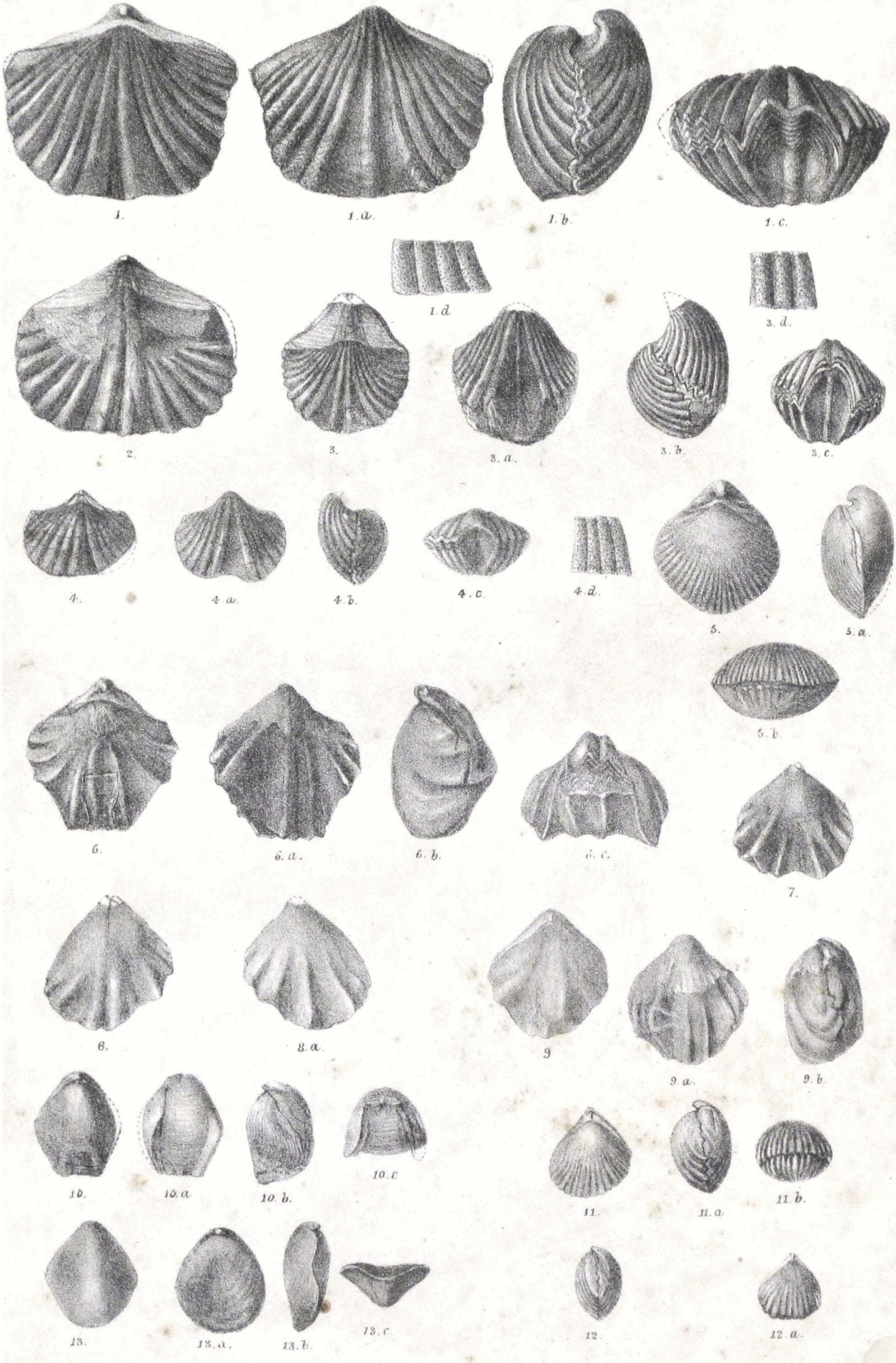

1.
1.a.
1.b.
1.c.
1.d.
2.
3.
3.a.
3.b.
3.c.
3.d.
4.
4.a.
4.b.
4.c.
4.d.
5.
5.a.
5.b.
6.
6.a.
6.b.
6.c.
7.
8.
8.a.
9
9.a.
9.b.
10.
10.a
10.b.
10.c
11.
11.a.
11.b.
12.
12.a.
13.
13.a.
13.b.
13.c.

PLATE III.

Kuling Series.

FIGS. 1, 2. SPIRIFER TIBETICUS, *Stoliczka*, p. 28. Fig. 1, Specimen with smaller and more incurved beak, and a narrower area; Fig. 2 Specimen with less incurved beak, and a larger area; from the Carboniferous rocks of Spiti.

FIG. 3. SPIRIFER ALTIVAGUS, *Stoliczka*, p. 28. The only specimen yet known, found with the former.

Lilang Series.

FIG. 4. SPIRIFER LILANGENSIS, *Stoliczka*, p. 38, from Lilang on the Lingti River; *Lilang series.*

FIG. 5. SPIRIFER SPITIENSIS, *Stoliczka*, p. 39, from Lilang on the Lingti River.

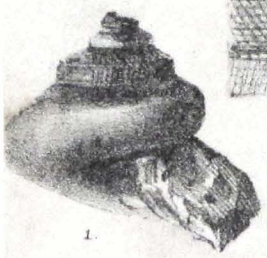
FIGS. 6-9. RHYNCHONELLA MUTABILIS, *Stoliczka*, p. 40. Fig 6 is the most regular and common form; Fig. 7, specimen with only two unequal plaits in the sinus; 8, rather depressed specimen with only one plait; 9, inflated specimen with slightly prolonged fold, and with only two lateral plaits. All from Lilang, on the Lingti.

FIG. 10. RHYNCHONELLA THEOBALDIANA, *Stoliczka*, p. 41, from Muth.

FIGS. 11-12. RHYNCHONELLA SALTERIANA, *Stoliczka*, p. 41, Fig. 11, Specimen from Lilang; Fig. 12, specimen from the neighbourhood of Hallstadt in the Austrian Alps.

FIG. 13. RHYNCHONELLA RETROCITA, (*Suess*) var. ANGUSTA, *Stoliczka*, p. 42, from Lilang. *Lilang series.*

All the specimens figured are in the Geological Survey collection.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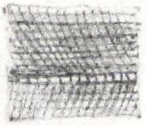
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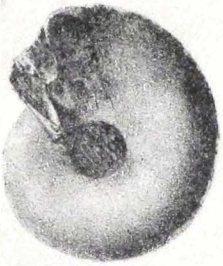
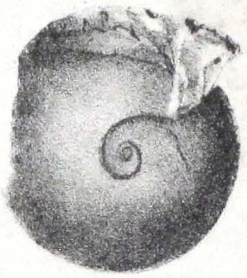

1.a.


3

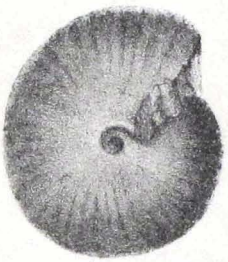
3.b.


3.a.

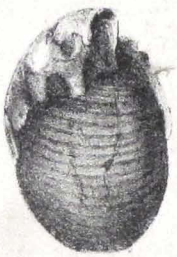

2.b.

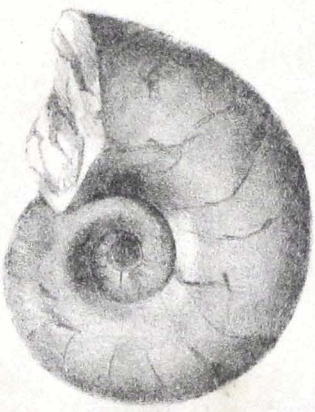

2.a.


2.c.

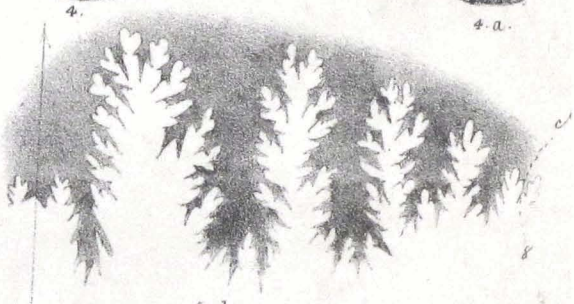

4.

4.b


4.a.


2.


2.a.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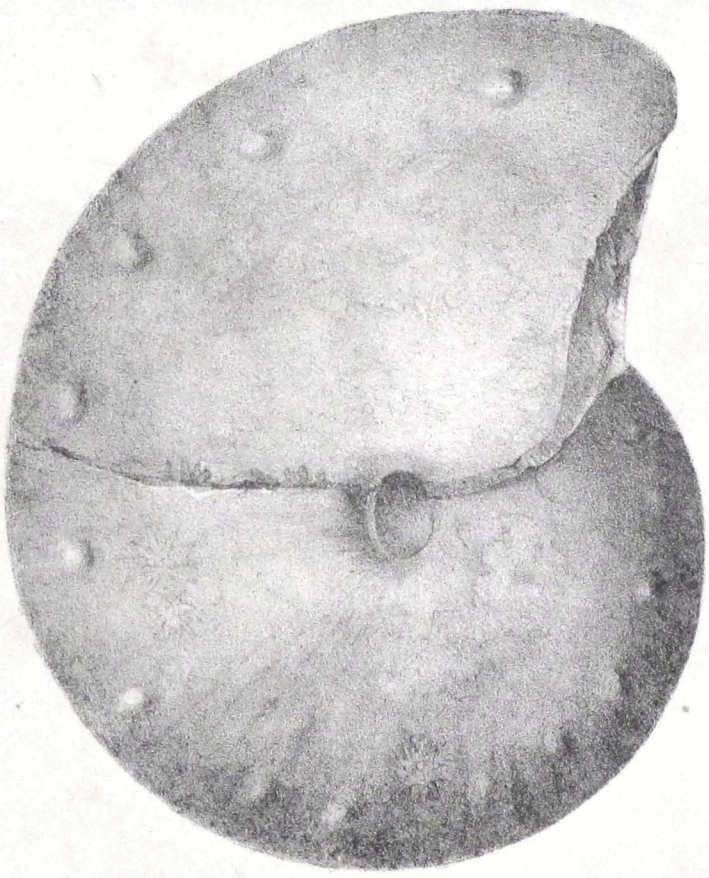
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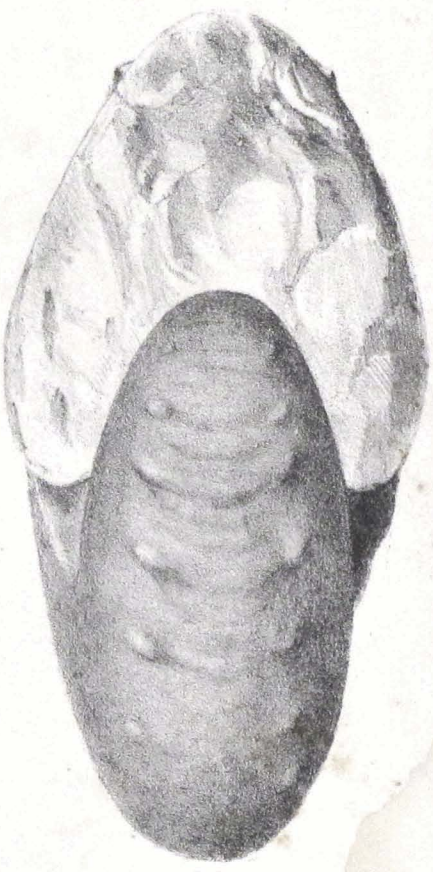

5.a.

PLATE IV.

Lilang Series.

FIG. 1. PLEUROTOMARIA STERILIS, *Stoliczka*, p. 46. The last whorl is devoid of the shell; Fig. 1*b* shows the striation on the whole breadth of one whorl; from Lilang, on the Lingti.

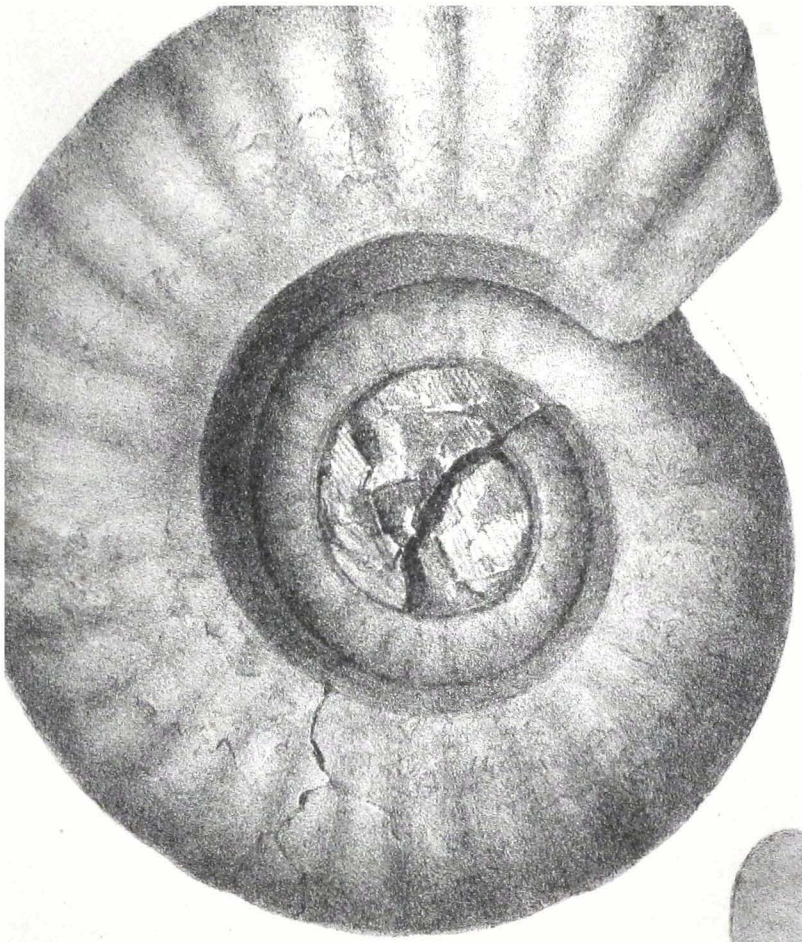
FIG. 2. NAUTILUS SPITIENSIS, *Stoliczka*, p. 49. Fig. 2*b* the concave, 2*c* the convex view of one septum; 2*d* shows a portion of the reticulate striation of the shell surface. From Lilang.

FIG. 3. CLYDONITES HAUERINUS, *Stoliczka*, p. 50, 3*b* shows the outline of a septum from another specimen not so perfect. From Lilang.

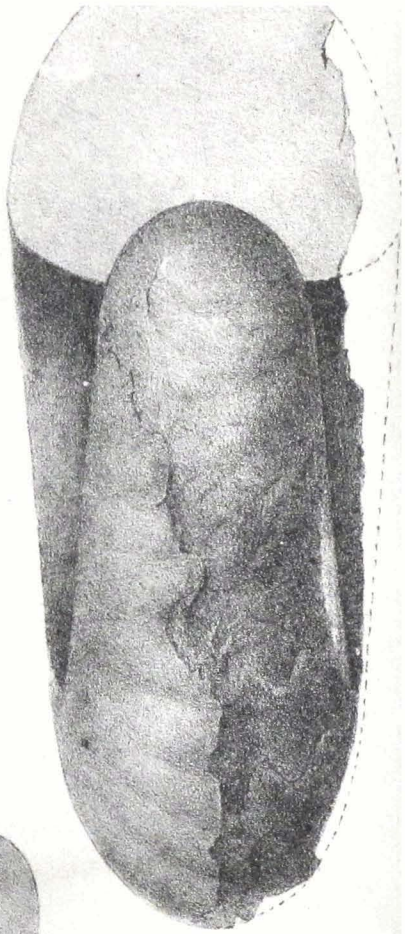
FIG. 4. CLYDONITES OLDHAMIANUS, *Stoliczka*, p. 50, 4*b* shows the outline of a septum of the same specimen: Lilang.

FIG. 5. AMMONITES MEDLEYANUS, *Stoliczka*, p. 54, probably from Kuling in the Pin valley.

All the specimens are in the Geological Survey collection.

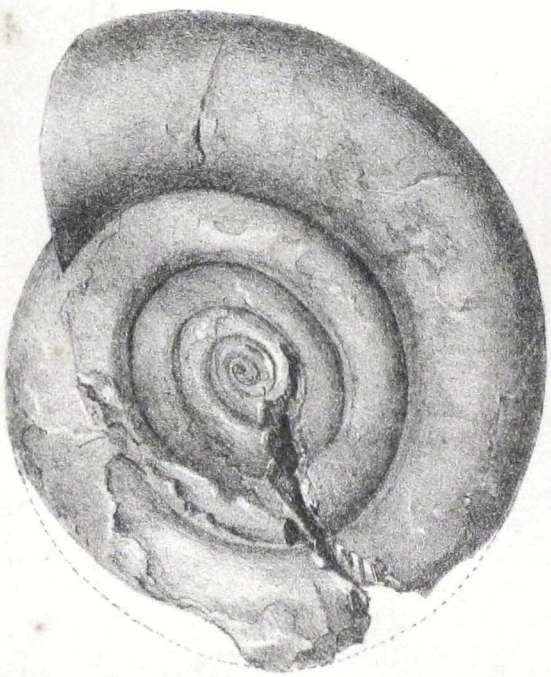


1.



1. a.

2. a



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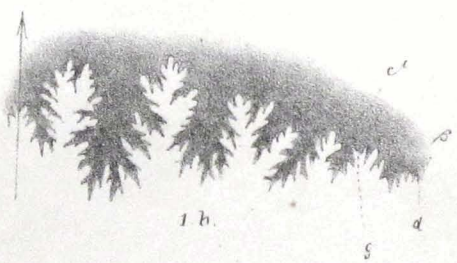
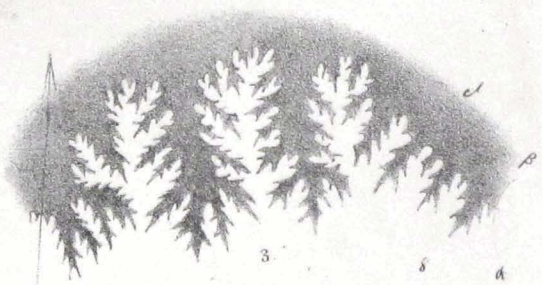




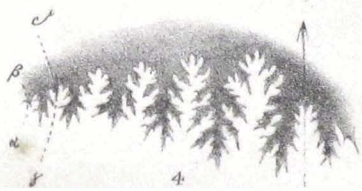


PLATE V.

Lilang Series.

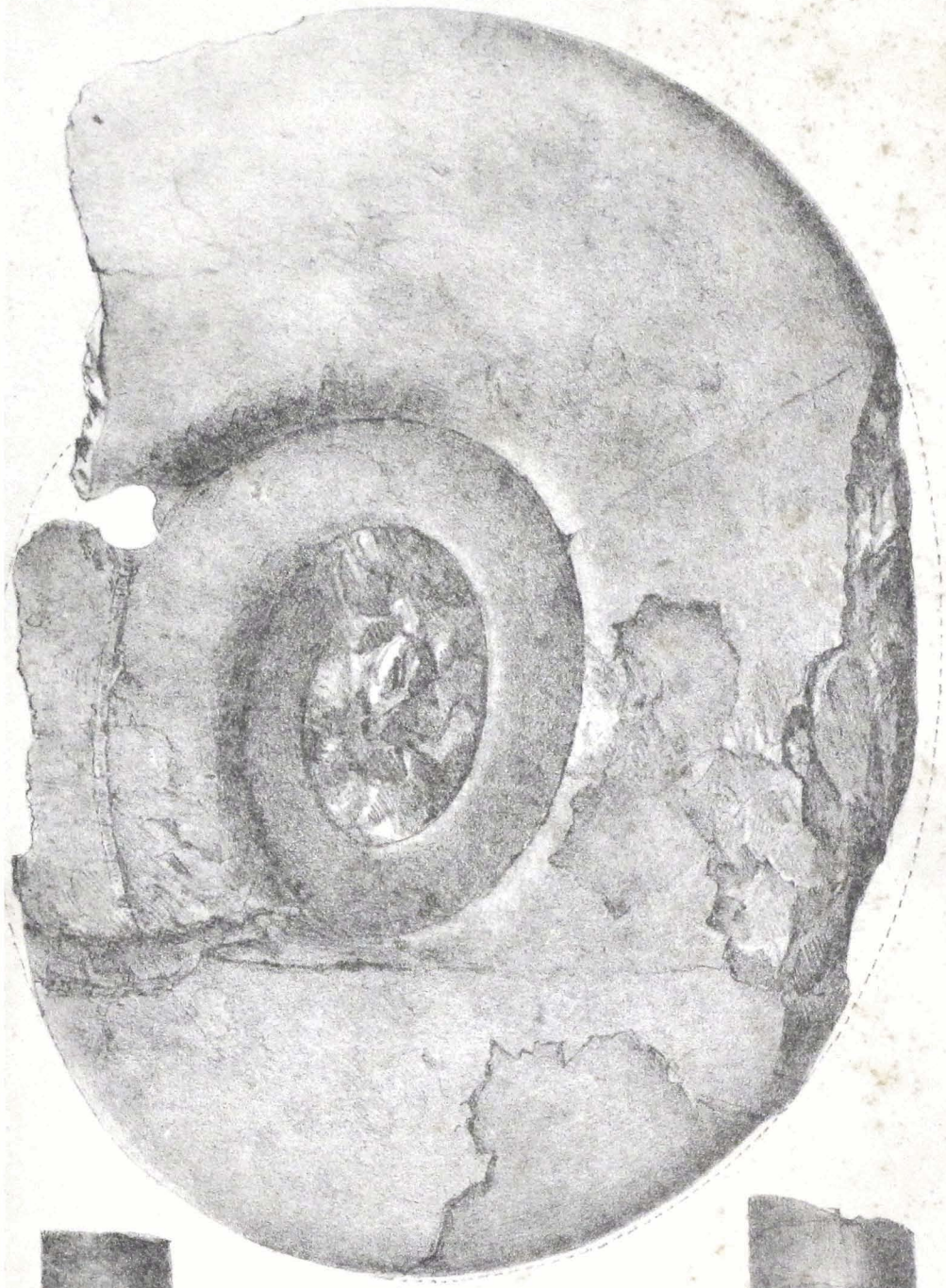
FIG. 1. AMMONITES MALLETIANUS, *Stoliczka*, p. 58, the only specimen yet known; from Lilang.

FIG. 2. AMMONITES BATTENI, *Strachey*, p. 59, variety with narrow but thick whorls; from Lilang.

FIG. 3. AMMONITES BATTENI. Outline of a septum from specimen figured on Pl. VI. fig. 1.

FIG. 4. AMMONITES DIFISSUS, *Hauer*, p. 53, outline of a septum of a large specimen.

All belong to the *Lilang Series*, and are in the Geological Survey collection.



1.

1.a.

3.

3.a.

2.a.

3.b.

2.

4.a.

4.

5.a.

5.

6.a.

6.

H. L. Fraser lith

T. Oldham direx.

Calcutta.

1.

1.a.


1.b.


2.a.


3.a.


4.


4.b.


1.


1.a.

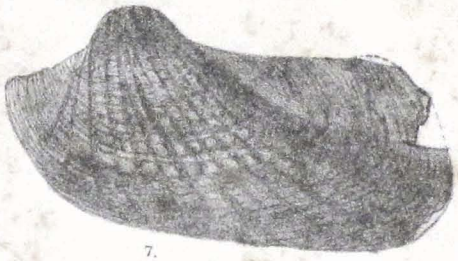

3.

2.


4.a.


5.b.

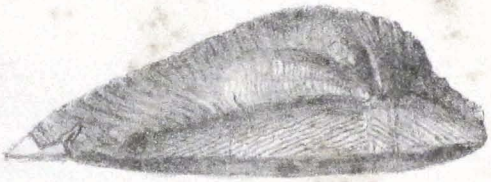

6.a.


7.

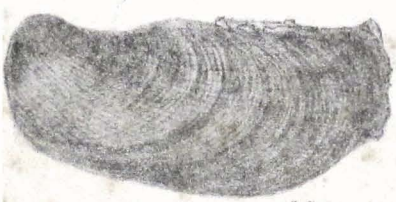

5.

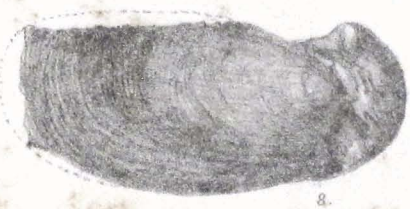

5.a.


6.


7.a.


7.b.


8.a.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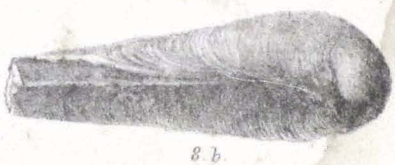

8.b.

PLATE VIII.

Lower Tagling Limestone.

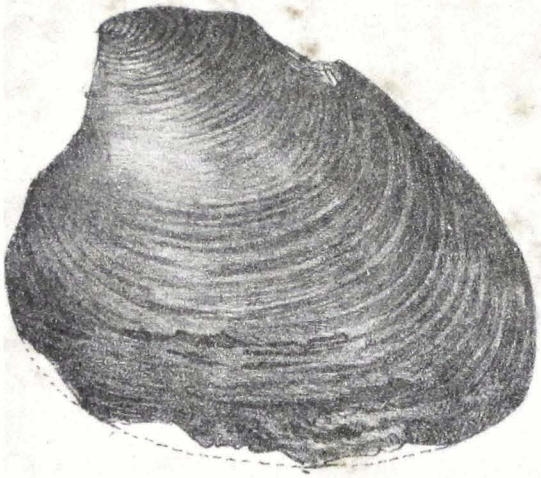
FIGS. 1-4. BELEMNITES BISULCATUS, *Stoliczka*, p. 78, specimens of different size and variable sections; from the South-west of Gieumal.

FIGS. 5-6. BELEMNITES TIBETICUS, *Stoliczka*, p. 79. Figs. 5 and 5*a*, are front and back views of a large specimen; Fig. 6*a*, side view of a much thinner specimen without any trace of a furrow; from Gieumal.

Spiti Shales.

FIG. 7. MACRODON EGERTONIANUM, *Stoliczka*, p. 89. From Gieumal.

FIG. 8. AUCELLA LEGUMINOSA, *Stoliczka*, p. 88. Fig. 8 ventral, 8*a* back, 8*b* front, view; from the neighbourhood of Kibber.



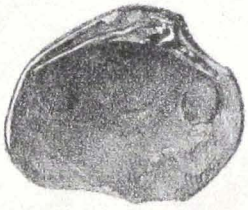
1.

1.b.

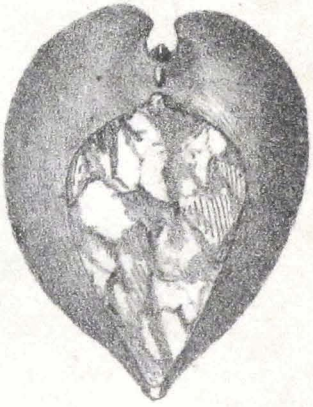
1.a.

2.

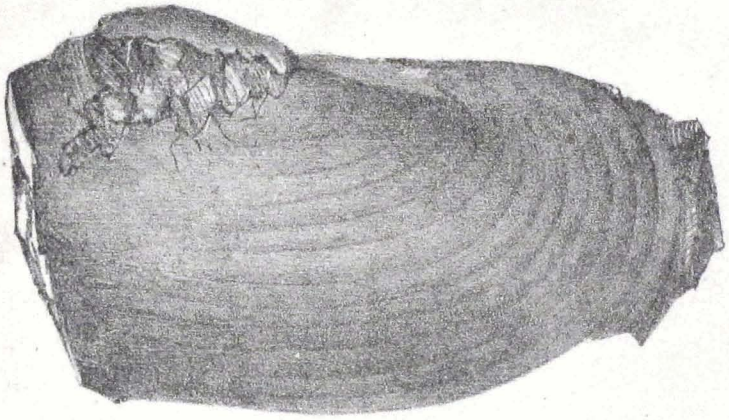
2.a.



3.



4.b.



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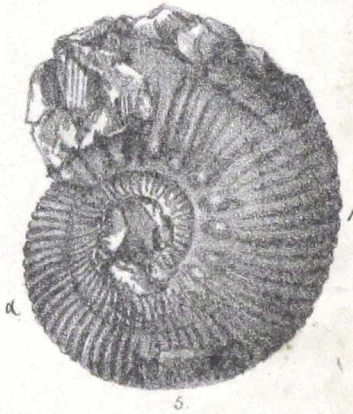
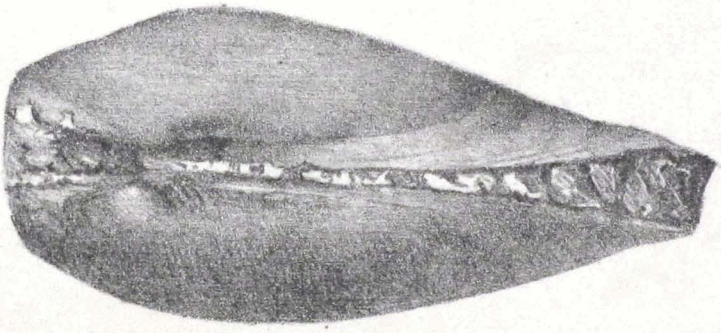


5.



4.a.

5.a.

PLATE VI.

Lilang Series.

FIG. 1. AMMONITES BATTENI, *Strachey*, p. 59, variety with compressed and high whorls, from Lilang.

Lower Tagling Limestone.

FIG. 2. AVICULA PUNCTATA, *Stoliczka*, p. 76. Fig 2*a*, shows the convexity of the shell; from the north of the Manirang pass.

FIGS. 3-6. BELEMNITES BUDHAICUS, *Stoliczka*, p. 78, views of different fragments of the same species; from the South of Gicumal.

All the specimens are in the Geological Survey collection.

PLATE IX.

Spiti Shales.

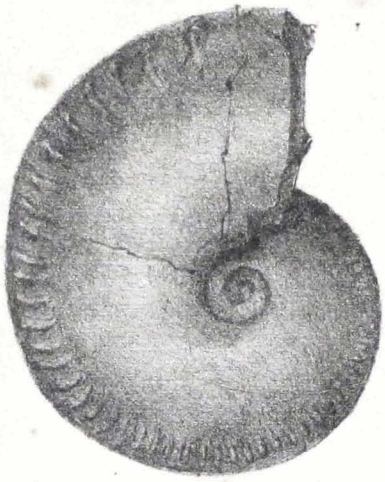
FIG. 1. ASTARTE SPITIENSIS, *Stoliczka*, p. 91, outer, side, and inner, views of the same shell; from the neighbourhood of Kibber.

FIG. 2. ASTARTE HIEMALIS, *Stoliczka*, p. 91, Fig. 2, 2*a*, side and front views of a small but perfect specimen: Fig. 3, inner view of another specimen; both are from the neighbourhood of Kibber.

FIG. 4. HOMOMYA TIBETICA, *Stoliczka*, p. 92, Fig. 4 side, 4*a* upper, and 4*b* frontal, view of a tolerably complete cast; from near Gieumal.

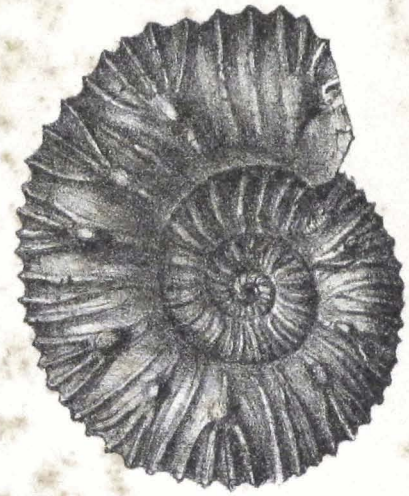
FIG. 5. AMMONITES THEODORII, *Oppel*, p. 99, Fig. 5, side view of a cast; Fig. 5*a* front view of a portion of it, a piece of the outer whorl having been broken away, to show the ornamentation on the inner volutions better. From Spiti, collected by Capt. Hutton.

N. B.—This figure is erroneously quoted on page 99 as Pl. IX. Fig. 4, instead of Pl. IX. Fig. 5.



1.

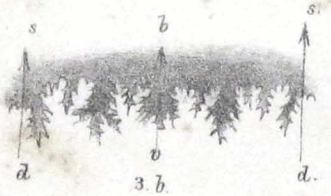
1.a.



2.

1.b.

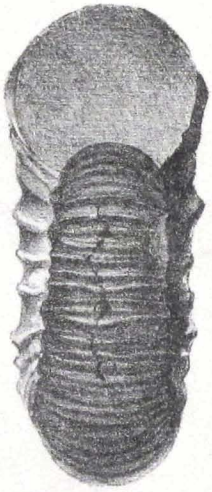
3.c.



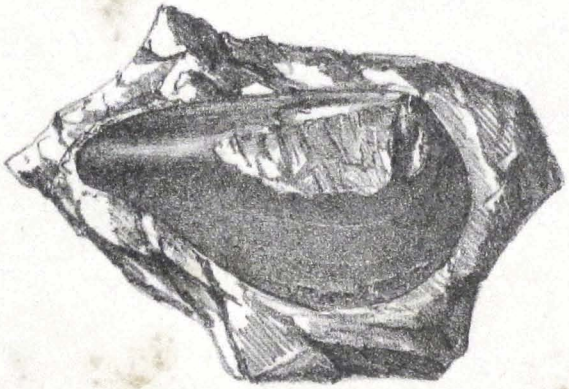
3.b.

3.

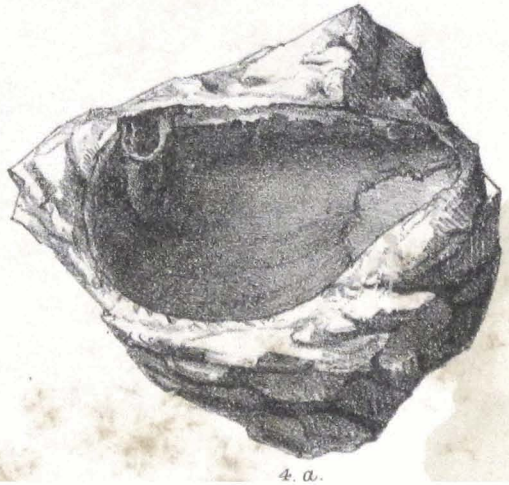
3.a.



2.a.



4.



4.a.

PLATE X.

Spiti Shales.

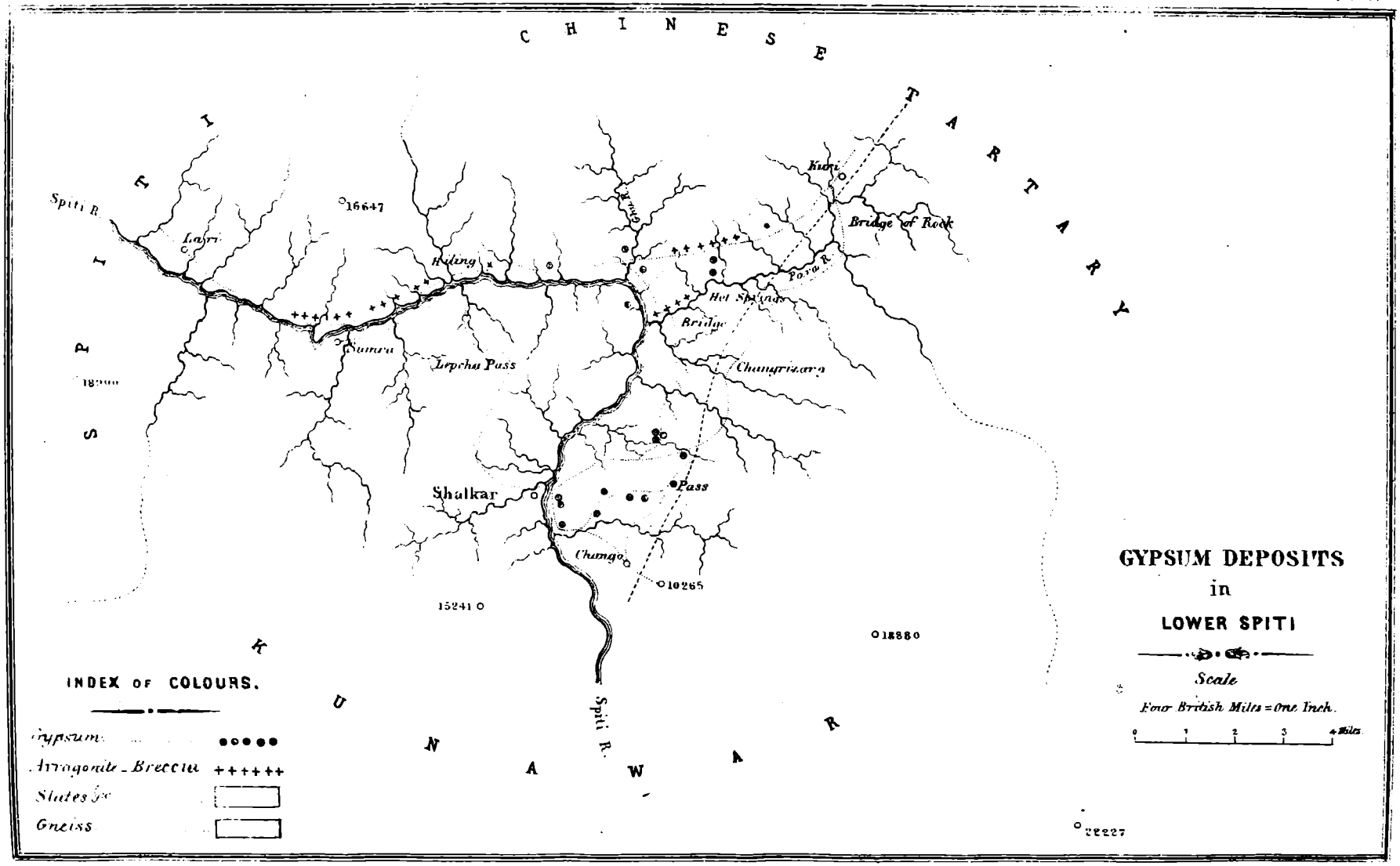
FIG. 1. AMMONITES NIVALIS, *Stoliczka*, p. 106. Side and front views and outline of a septum of a specimen from Kibber.

FIG. 2. AMMONITES HYPHASIS, *Blanford*, p. 97, from near Gieumal.

FIG. 3. ANISOCERAS GERARDIANUM, *Stoliczka*, p. 110, from Spiti, collected by Capt. Hutton.

Gieumal Sandstone.

FIG. 4. ANATINA SPITIENSIS, *Stoliczka*, p. 115, inner view, and cast impression of the same specimen; from near Gieumal.



Lith. by H.M. Smith, Surv. Genl's Office, Calcutta April 1865.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

On the GYPSUM *of* LOWER SPITI, *with a list of* MINERALS *collected in the* HIMALAYAS, 1864, *by* F. R. MALLET, ESQ., *Geological Survey of India.*

OF the different observers who have visited lower Spiti few have omitted to notice the deposits of gypsum which occur there. The appearance of these is such that they can hardly fail to arrest the attention, and they form one of the many objects of interest in this valley.

As my own observations have led me to conclusions as to their origin and relations, different from those of my predecessors, whose writings I have seen, I have been led to pen the following short note regarding them.

Dr. Gerard, 1832.

Dr. Gerard (Observations on the Spiti valley, Asiatic Researches, Vol. XVIII) says, "the soil itself appears argillaceous, with beds of gravel, clay, and marle, deposits of gypsum, and a cineritious-looking rubble, indicating coal or plumbago."

Capt. Hutton, 1841.

Captain Hutton, who visited this region many years ago, refers to them, (Journal As. Soc. Bengal, Vol. X., p. 198, 1841,) and classes them with the alluvium, referring both to a salt lake, which he supposes at one time to have filled the entire valley, from whose waters the gypsum was chemically

deposited, "while the streams from the snows were bringing in large quantities of fine alluvial particles, such as sand and clay and water-worn stones of various sizes." He notices the fact of their being confined to the lower part of the valley.

Genl. Cunningham, 1844.

Genl. Cunningham also mentions that "about the junction of the Petti and Sutlej, the gneiss would seem to yield by degrees to limestone, slate, gypsum, and crystalline sandstone." (General Description of Kunawar, Journal As. Soc. Bengal, Vol. XIII., p. 175, 1844.)

Capt. Hay, 1850.

Capt. Hay (ibid, Vol. XIX., p. 434, 1850) also notices the occurrence of gypsum and alum, and states them to be "in connexion with the beds of red sandstone."

Geological relations.

These deposits appear, then, to have been generally classed either with the alluvium, or with the crystalline and older rocks of the district. From my own observations I am convinced they are unconnected *directly* with either, but as I believe they are dependent in their position and origin on the latter, I must mention briefly the succession of these rocks, before describing the gypsum itself.

General section.

Commencing at the lower end of the valley we find gneiss east of Chango and Kuri. In mineral character it is more usually fine-grained and hard, often very quartzose; one variety containing a considerable proportion of black mica, another being without this mineral, the two forming alternate layers, giving the rock a banded appearance. Not uncommonly it is coarsely crystalline, and intersected by albitic veins in which schorl occurs plentifully, besides more rarely garnet and kyanite. The boundary of the gneiss is found between the Chinese village of Kuri, and the rock bridge close by, then down the Para river, and turning nearly south passes a little East of Chango. Resting on the gneiss is a

Gneiss.

great thickness of highly pyritous dark grey and black slates, interstratified with pyritous quartzite and some limestone.

Dark pyritous slates.

These rocks are found nearly as far as Po; the beds north of the Para river appearing to be the same as those exposed in the stream at Lari. Here we see some 600 or 800 feet of hard black splintery slate, the lower part being speckled with innumerable minute cubes of pyrites. Higher up the crystals are fewer in number and larger in size, being often associated together in small concretions of the slates. The latter are covered by quartzites, also pyritous, and often honeycombed from the removal of this mineral; small crystals of it may also be found scattered through the debris of these rocks. Higher up, both in the valley and in the section, is an immense thickness of limestone, in some parts containing numerous fossils. Above this again at Gieumal, Kibber, &c., we find about 400 feet of black concretionary shales, highly fossiliferous and also pyritous. They in turn are covered by beds of yellow sandstone, limestone and shale again. This immense thickness of stratified rocks, belonging to several different formations, has been described in detail in the foregoing report. At present we are concerned with their mineral characters only, and not with their geological relations.

Fossiliferous shales.

Limestone, &c.

Perhaps the largest of these gypseous masses, and from its position one of the most conspicuous, is that opposite Shalkar, on the other side of the Spiti. The slope of the hill is here very steep, and the deposit may be distinguished by its color, at about 600 feet above the river, the slope below being strewed with its fragments. The deposit is a large amorphous mass, resting on the face of the rock, the lower part concealed by breccia and talus. It is pure and massive, but by exposure becomes soft and partially disintegrated, so as to be easily cut by the knife.

Gypsum at Shalkar.

The unaltered rock is, however, of a snowy whiteness and crystalline texture, much resembling crystalline limestone, which it also nearly equals in hardness. Traversing the mass are a few small lenticular bands of compact dove-colored carbonate of lime. In front of the deposit, and partially covering the lower part, some breccia occurs, formed out of pieces of this limestone, with fragments of the stratified rocks on which the deposit rests, some clay, and large but coarse crystals of selenite which acts as the cement, the material of which has evidently been derived from the original deposit by solution. Close to this, and about 150 feet lower, a smaller mass is observable perched on the bare rock. No alluvium occurs in connexion with either of these, nor indeed on this portion of the slope. Alluvium is abundant on the Shalkar side of the river, but here I observed no gypsum. About 400 yards from the top of the pass between Changrizang and Chango on the Northern side a small deposit occurs, another having been previously met with lower down. Half a mile or so from the summit, on the Chango side, a larger mass is seen, another 300 yards further on, and two more occur between this and Chango. The first rests on pyritous slates, and the last two on the debris of these rocks, being themselves somewhat broken up and mixed with it. Another mass is met with between Chango and Shalkar. In mineral character they all resemble the deposit at the latter village, but no breccia occurs with them. On the road from Shalkar to the bridge over the Para river five or six masses are seen in a space of about 600 by 300 yards; I observed three others in different localities near the mouth of the Ghu stream, one about 800 feet above the Spiti. Again, between Huling and this stream, gypsum is met with, but this differs from the preceding in its mode of occurrence, as it appears to be *interstratified*

No alluvium.

At Chango pass,

rests on slates.

Near Huling,

with the slaty and quartzose beds, although it undoubtedly has no more connexion with them than a band of intrusive trap in a similar position, having evidently been deposited in an opening between the strata. It may be observed for some distance, being associated with crystalline carbonate of lime, which is almost undistinguishable from it in outward appearance.

appears interstratified.

From the various positions and modes of occurrence of these masses, it is at once evident that they do not belong to the older rocks of the valley, since they are all, with one exception, explained above, superficial; and it is equally clear that they have no connexion with the alluvium. If these masses had been chemically deposited from a large body of water in which strata were being formed mechanically at the same time, we should expect to find in them at least some traces of stratification, whereas none such exist, but the deposits are simply *amorphous masses.* How, if they had been formed in this way, could a mass occur between the beds of ancient stratified rock, or be mixed up with the angular debris, which is evidently of atmospheric origin? Moreover, there is no community of level between the different deposits, and they generally are found where there is *no* alluvium. They occur near the Spiti at Chango, and close to the top of the pass between this and Changrizang, a difference little short of 3,000 feet; and the latter locality is, if I mistake not, considerably above the highest level of any alluvium.

Position in all cases superficial.

If then they are not of lacustrine origin, there is but one other agent to account for them, namely, thermal springs, which account perfectly for their peculiarities of position, &c. Thermal springs may form such masses on the face of the older rocks, or between their strata, or amongst their debris, and the deposits will be unstratified and amorphous, and occur at any level.

Origin from thermal springs

Independently, however, of these considerations, which are of themselves I think sufficient to determine the origin of the gypsum, there is the additional fact tending still more strongly to confirm this opinion, that gypsum, with carbonate of lime, *is being deposited by thermal springs at the present time in this very region.*

Formation at present time,

On the right bank of the Para river, about $1\frac{1}{2}$ miles from its mouth, we find the process going on. The water rises through the mass of gypsum and carbonate of lime into small pools formed by the natives for bathing, issuing at the surface with a temperature of 116°·5 F. The air around is strongly tainted by sulphuretted hydrogen which rises in bubbles through the water. By its decomposition it originates sulphur in a native state, which is found in microscopic crystals, or forming a film on the surface of the water. The calcareous deposit forms a large thick mass extending several yards along the river, and not less than 15 or 20 feet high; besides one or two smaller ones. At one end of it the carbonate of lime is seen in curved layers, from one to two inches thick, beneath which the white gypsum is exposed. On the hill side above a deposit occurs similar to those previously mentioned. At these springs, it will be observed, there is the same association of sulphate and carbonate of lime as in the deposits at Shalkar and near Huling.

near Para river.

In the same region, and, as I am inclined to believe, connected in origin with the gypsum, a rock may be observed, generally breccia, occasionally conglomerate, cemented by *arragonite.* The latter variety may be seen near the wooden bridge over the Para, the pebbles and boulders of gneiss, quartzite, slate, &c., forming the river alluvium being firmly united by this mineral. Loose talus and debris is similarly cemented into a breccia. It occurs at intervals from west of Sumra along the north

Breccia, Conglomerate.

side of the Spiti to Huling. The arragonite is usually radiated fibrous, rarely in small radiating crystals, and sometimes lining cavities in fibrous mammillary coats one or two inches thick. It is pure white, and opposite Sumra very good specimens of the mineral may be obtained. The rock is also seen along the road to Kuri above the hot springs, and probably occurs in many other places. Higher up the Spiti valley such debris often forms a breccia, but I have observed it cemented by arragonite only below Sumra.*

Gypsum all on slates.

The question of the original source whence the gypsum of these deposits has been derived receives elucidation from a fact observable on the accompanying map (Pl. I.) namely, that of the different masses which I have observed, about 20 in number, *all* are on the slaty rocks,—I have not seen one resting on the gneiss. There can scarcely therefore be any question that the mineral is derived from the slaty rocks, and its origin is undoubtedly to be attributed to the combination of iron pyrites and lime, which we find in these—a combination well known to produce this mineral; the bisulphide of iron by the action of air and moisture forming with the carbonate of lime hydrous sulphate of lime or gypsum, and carbonate of iron with free carbonic acid—$2\,(CaO,CO_2) + 4HO + FeS_2 + 7O = 2\,(CaO,SO_3 + 2HO) + FeO,CO_2 + CO$.

Formation of

The carbonate of iron is very prone, by oxidation, to pass into hydrous peroxide or limonite, and we very commonly find the small cubes of pyrites altered to the latter mineral either superficially or wholly. In the quartzite, as before remarked,

Limonite.

* I observed one exception to this at Tshissigaong in upper Spiti, but here also the rock is associated with Gypsum, which occurs sparingly disseminated in crystals through the black shales above the limestone.

they are very frequently entirely removed, leaving the rock full of angular little cavities.*

Arragonite.

The carbonic acid set free in this process may, I think, have been very probably the origin of the arragonite-breccia. Percolating with water through the calcareous strata, it exerted its dissolving action, and forming a solution of carbonate of lime, furnished the material with which the breccia and conglomerate are cemented. The amount of carbonic acid soluble in water being dependent on the temperature, and the amount of carbonate of lime on that of the carbonic acid, any increase in the temperature of the saturated solution must cause a deposition of carbonate of lime. As therefore the mean temperature decreases with the altitude,† the solution in percolating from any given elevation to one considerably lower must part with some of its lime, and this may be at least one way in which the arragonite has been formed.‡

Epsomite.

Another product of the decomposing pyrites is sulphate of magnesia, which, in many places, occurs plentifully as an efflorescence on the black slate; were it worth the trouble a considerable quantity might be procured annually by simple collection and by lixiviating the loose slate debris.

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* Two interesting papers on the occurrence of gypsum on the southern side of the Himalayas, by Capt. Herbert and Capt. Cautley, with remarks on the latter by the Rev. R. Everest, may be found in the Asiatic Researches, vol. XVIII, pt. I, p. 216, and Jour. Asiat. Soc. Bengal, vol. I, pp. 289 and 450. *On some points* their ideas as to the relations of these deposits are very similar to those expressed above with regard to the Spiti ones.

† Hooker (Himalayan Journals) gives the difference as 350 feet for 1° F. for elevations between 10,000 and 14,000 feet.

‡ If it be true that the formation of arragonite *under all circumstances* is due to high temperature of the solvent, this explanation would not suffice.

Limitation of area.

Why the gypseous deposits are confined to the region near the junction of the Para and Spiti, while the pyritous beds extend several miles higher up the valley, is explained by the fact that, although gypsum may be formed through the strata by decomposition, (as in the black shales at Tshissigaong, &c., and at the Niti Pass,) it cannot be collected and formed into *masses* without the agency of thermal springs, and it is simply necessary therefore to suppose that the latter have been always confined to nearly the same region as that in which they are found at present.

Hot springs without gypsum.

Hot springs occur on both banks of the Para within a few yards of each other, but while those on the right bank have formed the large calcareous masses before described, those on the left have produced none; the explanation of this probably being, that the latter rise through gneiss for the greater part of their course, and the former through the slates.

Former greater extent.

It appears then, that in former times thermal springs existed in this region, probably in greater numbers than at present, though it is very unlikely that all the gypseous masses were formed at one time. The same spring may have often ceased to flow in one place, and have subsequently broken out in another. Some may have been extinct for ages, while, as we have seen, in at least one locality, the mineral is still being formed at the present day. There is further proof of this, if I am right in referring the gypsum and arragonite to a common origin, for, at the wooden bridge over the Para, I observed pebbles of the former mineral in a conglomerate united with arragonite. The gypsum contemporaneous with this arragonite must be, therefore, of more recent date than that included in the conglomerate.

The compact unaltered portions of the gypsum are of a snowy whiteness, and would form a beautiful material for ornamental

they are very frequently entirely removed, leaving the rock full of angular little cavities.*

Arragonite.

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Epsomite.

Another product of the decomposing pyrites is sulphate of magnesia, which, in many places, occurs plentifully as an efflorescence on the black slate; were it worth the trouble a considerable quantity might be procured annually by simple collection and by lixiviating the loose slate debris.

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† Hooker (Himalayan Journals) gives the difference as 350 feet for 1° F. for elevations between 10,000 and 14,000 feet.

‡ If it be true that the formation of arragonite *under all circumstances* is due to high temperature of the solvent, this explanation would not suffice.

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Hot springs without gypsum.

Hot springs occur on both banks of the Para within a few yards of each other, but while those on the right bank have formed the large calcareous masses before described, those on the left have produced none; the explanation of this probably being, that the latter rise through gneiss for the greater part of their course, and the former through the slates.

Former greater extent.

It appears then, that in former times thermal springs existed in this region, probably in greater numbers than at present, though it is very unlikely that all the gypseous masses were formed at one time. The same spring may have often ceased to flow in one place, and have subsequently broken out in another. Some may have been extinct for ages, while, as we have seen, in at least one locality, the mineral is still being formed at the present day. There is further proof of this, if I am right in referring the gypsum and arragonite to a common origin, for, at the wooden bridge over the Para, I observed pebbles of the former mineral in a conglomerate united with arragonite. The gypsum contemporaneous with this arragonite must be, therefore, of more recent date than that included in the conglomerate.

The compact unaltered portions of the gypsum are of a snowy whiteness, and would form a beautiful material for ornamental

purposes. All of it, from its apparent purity and freedom from iron, &c., might be manufactured into very superior plaster of Paris. One fatal bar, however, exists to its economic employment, namely, the mountain carriage across the entire breadth of the Himalayas. The existence of gypsum near the southern boundary of the hills makes it quite certain that these deposits could never be worked advantageously, at least for employment in India Proper.

List of Minerals collected in the Himalayas—June, September 1864.

Native Sulphur,—from Puga. This valley is situated between Lake Chomoriri and the Indus at an elevation of about 14,500 feet; two marches from Chomoriri and one from the river. The stream which drains it flows through a flat marshy plain, one to two miles wide. Some distance below the mines the valley contracts to a deep narrow gorge. At the mines the plain is about half a mile across; the hills on the south side, which are crossed on the route from Chomoriri, being formed of coarsely foliated orthoclase-gneiss, which becomes more schistose and schorlaceous near Puga. The hills on the north side of the valley are formed, in the lower part, of thinly foliated micaceous quartz-schist passing into mica-schist, and it is at the foot of the hill in this rock that the 'mines' are situated. Lower down the valley chlorite-schists and serpentine are met with.

The quartz-schist at the diggings is thinly foliated, greatly contorted on a small scale, and considerably altered locally by the agencies which have formed the sulphur and other minerals. It is intersected by many small clefts or fissures, and it is in these, and between the laminæ of the schist, that the chief portion of the sulphur is found. It frequently fills them completely in the massive form, but oftener it lines the opposite walls with a thick coating of small transparent crystals.

Gypsum occurs in large irregular masses through the schist. It has a finely saccharine appearance, but is dull, opaque, and rough to the touch, unlike the crystalline translucent mineral of Spiti. Crystals of sulphur are commonly disseminated through it, but the workable mineral is almost confined to the fissures of the schist. *Potash-alum* is also found here in veins one to two or three inches thick, but the quantity of it is small, and not sufficient to render it worth extraction. Still rarer is common white *opal*, which I only observed in one spot associated with gypsum.

The mines consist of vertical holes about eight feet deep, from the bottom of which the rock is excavated laterally for two or three yards. As the mineral is so near the surface, it is easier to open a new hole than to carry the lateral excavations further from the old one. If the latter plan were pursued, besides the greater heat and want of ventilation, artificial light would become necessary.

There are a dozen or more such holes extending along the foot of the hill, but only three or four were being worked when I was there, most of the others being abandoned and choked up with rubbish. The temperature inside is very high, almost oppressively so, which appears due to the copious hot springs rising close by, which must heat the surrounding rocks considerably.* The appearance of the interior is very pleasing from the contrast of the snowy gypsum with the brilliant sparkling crystals of yellow sulphur.

There can be little doubt that these minerals, like the gypsum of Spiti, have been formed by thermal springs; for besides their mode of occurrence through the fissures of the schist, the springs close by now

* These springs rise in the middle of the borax-grounds on the right bank of the stream, at temperatures from 135° to 178° F., the hottest being in a violent state of ebullition. The borax deposits are in themselves very interesting, but it is unnecessary to describe them here, as the subject has already been fully treated on by M. Marcadieu ("Selections from the Public Correspondence of the Punjab Administration," No. XII, Vol. II, 1855, where a map of the valley is given.)

deposit small quantities of sulphur at the surface. The principal mineral deposits are very probably below the surface. M. Marcadieu believes that sulphur is being formed at present in the mines from the vaporous condition, which appears by no means improbable.

There is no evidence to show from what chemical changes the gypsum, &c., have been derived; but from the difference in the association of the minerals here from those occurring with the gypsum of Spiti, these changes also would seem to have been of a somewhat different character. The rocks in the vicinity also differ from those in Spiti. Instead of the pyritous slates and quartzites of the latter region, the rocks at Puga are of the gneissose series.

The mines belong to the Maharajah of Kashmir, one of whose sepoys is on the spot in charge; but, as usual in such cases, he was not very communicative, or inclined to give much information on the subject. He informed me, however, that the annual yield of sulphur is about 500 or 600 maunds, but fluctuates much in different years. The amount depends chiefly on the weather. In this rigorous climate, at an elevation of 14,500 feet above the sea, where snow not unfrequently falls at midsummer, the work can only be carried on for four months in the year. The method of purification is exceedingly barbarous. Only the purest ore is used at all, the poorer portions being thrown away, so that round the mouths of all the excavations are heaps of refuse containing a large percentage of sulphur. The best parts are broken up small and melted in pots, the temperature being of course kept as low as possible to prevent ignition. The stony impurities are then skimmed off as they rise to the surface, generally carrying with them a coating of solidified sulphur, so that the secondary refuse heaps after the fusing are also rich in the mineral. The sulphur is poured from the pots into copper basin-shaped moulds, about 7 inches diameter and 2 inches deep, and the cakes removed when cold. The fuel comes from the lower end of the valley, where

clumps of scrubby trees border the stream in the deep sheltered gorge, into which the valley becomes narrowed. The supply appears to be abundant; much more than sufficient for the small requirements of the sulphur diggings. The existence of such firewood in the vicinity is extremely fortunate, in a district where trees or shrubs of any kind are almost unknown. It would be very easy to devise a simple mode of purification which would obviate the present great waste, and probably nearly double the yield of sulphur.

Stibnite.—Just west of the fine Bara-Shigri glacier in Lahoul, which descends from a lateral gorge into the bed of the Chandra river, sulphide of antimony occurs in the gneiss. I did not see the mineral *in situ*. A loose block close to the glacier, containing a large proportion of pure mineral, was fully 18 inches in the shortest direction, showing that the vein cannot be less than this in one part. An analysis by Mr. Tween gave, besides antimony and sulphur, some iron, alumina, lime and chlorine, with traces of copper and arsenic. Associated with the stibnite in small quantity are zinc-blende, iron pyrites, and carbonate of iron (manganiferous) more abundantly.

Captain Hay, Commissioner of Kulu, formerly obtained some of this antimony for trial. If the vein is generally as rich as the blocks I saw, the ore could, I should say, be profitably brought across the Hamta Pass and freed from gangue on the south side, where wood is abundant. This is two long, or three short, marches, with a made road for the greater part of the distance. The pass is about 14,500 feet high, and rather below the perpetual-snow line. From the forests on the south side to Sultanpur the capital of Kulu is four marches. There is no wood applicable to the purpose on the north side of the pass.

Galena.—(*a.*) Near the village of Uchich, two miles above Manikarn in Kulu, is an old mine now abandoned, which is known throughout the district as a 'Silver Mine.' I failed to detect any trace of silver however, the only minerals observable being iron pyrites, with

a very small quantity of galena and arsenical pyrites. The galena is scattered very sparingly through the gangue (quartz rock) in far too minute quantity to be of any practical value. The specimens of it I examined were not argentiferous. The mine is in the form of a narrow vertical fissure 2 or 3 feet wide, accessible by two small entrances in the face of the precipitous cliff, and extending inwards for a few fathoms. Some silver may possibly have been found here formerly, which is now exhausted, but more probably the proprietor of the mine was misled by the silvery appearance of the galena.

(*b.*) A loose pebble from the bed of the Sutlej below Rampur—highly garnetiferous quartzose chlorite-schist with some galena.

Zinc-blende.—The ordinary dark brown opaque variety occurs sparingly disseminated through the gangue of the antimony at Bara Shigri.

Iron Pyrites.—(*a*). 200 to 400 feet above the Blini limestone at Simla some black shale occurs beneath quartzite. The shale is usually somewhat pyritous, and the mineral is occasionally found in small seams. By its decomposition alum is formed as an efflorescence on the shales.

(*b.*) From near Muttianna, where it is occasionally seen in chloritic schistose beds.

(*c.*) From the black slates of lower Spiti (p. 155).

Fluor-Spar.—A light green variety occurs very rarely amongst the minerals of the albite-granite veins at Wangtu Bridge (p. 12).

Chromic Iron.—Amongst the loose stones and debris scattered over the comparatively level ground bordering the Hanle-chu (river) pieces of chromic iron are not difficult to find in some places. The mineral generally has a more or less crystalline structure, sometimes largely so: Sp. Gr. = 4·208. I did not observe the ore *in situ*, but there can be no doubt of the pieces having been derived from the serpentinous rocks, which form much of the hills on either side, especially

on the west. Serpentine being the ordinary rock in which chromate of iron occurs, one would be pretty certain to find the mineral *in situ* by a little search through these beds. That it occurs in some quantity is probable from the size one sometimes sees scattered pieces. In the wall of the Hanle monastery I observed a cuboidal block 8 or 9 inches square. The same serpentine rocks occur in the lower part of the Puga valley 40 miles north-west of Hanle. I observed no chromate of iron here, though it may very likely exist.

Some specimens of the chromic iron are traversed by extremely thin seams of another chromic mineral, which outwardly much resembles Ouvarovite, but differs from it in composition. The chromate of iron has a slight tendency to break along these seams, both sides of which are then seen coated with very minute crystals of a brilliant emerald green color. Viewed under the microscope the faces of the crystals appear to resemble those of a rhombic dodecahedron. This is the form of Ouvarovite which also resembles the mineral in question in its action before the blowpipe. Both are found with chromic iron. Ouvarovite, however, differs considerably in composition and also in hardness ; (*a*) is an analysis of it by Komonen,* (*b*) one of the mineral in question by Mr. Tween.

(*a*)		(*b*)	
Silica	37·11	Silica	41·2
Oxide of chrome ...	22·54	Oxide of chrome ...	33·5
Alumina	5·88	Alumina ...	
Protoxide of Iron ...	2·44	Oxide of Iron	24·2
Magnesia	1·10	Magnesia ...	
Lime	30·34	Water...	1·1
Water	1·01		

In Ouvarovite the alumina replaces part of the chrome, the iron and magnesia replacing part of the lime. In (*b*) there is no lime, but the

* Phillips' Mineralogy by Brooke and Miller.

quantity of iron and magnesia is much greater. With regard also to the analysis (*b*) it should be mentioned, that the quantity of the mineral available for examination was so extremely minute as to render a quantitative determination very uncertain.

Micaceous Iron is occasionally met with in quartzite between Rampur and Gaora (p. 11) in thin seams parallel to the bedding. It also occurs similarly in quartzite below Manikarn.

Opal.—A common white variety, nearly opaque and of a porcellanic appearance, occurs with the gypsum and sulphur of Puga. It is the rarest of the minerals found there, having been seen in only one spot.

Diallage.—This variety of pyroxene occurs plentifully in the serpentine of the Hanle and Puga valleys. Loose blocks of the mineral, two and three feet diameter, are sometimes seen. It varies in colour from light to dark green, the principal cleavage planes having a brilliant pearly-metallic lustre. Diallage is also frequently disseminated in small crystals through the serpentine.

Hornblende.—In the bed of the Puga stream some distance from its mouth, amongst many other varieties of rocks, loose pieces of a binary compound occur, the base being felspathic, and traversed in every direction by long bladed crystals of dark green hornblende. This rock probably forms veins through the serpentine and chloritic beds of the vicinity.

Beryl is occasionally found in the albite-granite veins which traverse the gneiss at Wangtu bridge, and for some miles up the Sutlej and Wangur Rivers (p. 12); also in the similar veins of the Chandra valley above the Hamta Pass. The crystals are generally light blue, but only translucent, and so flawed as to be unfit for jewelry. They are usually small, the largest specimen of beryl from these localities that I am aware of, being one obtained by Mr. Theobald in 1861 a few miles above Wangtu bridge. This crystal (now in the Geological Survey Museum) is about $3\frac{1}{4}$ inches long and $\frac{3}{4}$ inch diameter. The

mineral appears confined to those parts of the rock in which tourmaline occurs, though the latter often abounds without any beryl accompanying it.

Garnet.—(*a.*)—The mica-schist of Jatog near Simla is highly garnetiferous, and by its weathering the crystals are set free in large numbers. In this way the roads which pass over this rock are thickly strewn with small garnets ; all are of the same form—a dodecahedron with truncated edges. (*b.*)—From the talcose schist between Gaora and Serahan, associated with staurotide. It occurs in dodecahedrons with polished faces and often very regular form. The edges are sometimes truncated, but this is exceptional. (*c.*)—From the gneiss north-east of Shalkar.

Epidote with felspar occurs in small irregular veins through the chlorite schists of the Puga and Hanle valleys, being well seen near the Hanle monastery. The epidote is usually granular, sometimes columnar, the crystals penetrating the felspar.

Muscovite.—The mica in the granite veins at Wangtu bridge is never intimately blended with the other minerals, but is generally scattered through the rock in individual crystals of some size. The largest plates are 5 or 6 inches diameter and 1 or 2 thick. In these, however, the form of the crystal is not so well defined as in some smaller ones. Some plates show by transmitted light portions of a series of concentric hexagons, the sides of which are parallel to those of the crystal. The colour is usually brown, rarely silvery white.

Uniaxial Mica.—Between Serahan and Tranda very dark brown uniaxial mica, with silvery flakes of muscovite through it, often occurs as a scaly aggregate, in layers through the micaceous strata (p. 11). Notwithstanding its uniaxial character it is not acted on by sulphuric acid.

Albite.—The granite veins at Wangtu are mainly composed of albite, and large cleavable masses of the mineral are seen unmixed

with any other. The colour is pure white; translucent, or in thin plates often semi-transparent (p. 12).

Very similar in mineral character are the veins which traverse the gneiss of the Chandra valley above the Hamta Pass. These vary in breadth from several feet to the fraction of an inch. The proportion of quartz and mica is usually small, the former sometimes occurring in transparent crystals. The mica is not found in as large plates as at Wangtu. Beryl is rare in these veins. Small garnets and black tourmaline common. The latter mineral appears to be generally more abundant in albitic crystalline rocks than in those containing orthoclase, and I have found beryl *only* in the former variety.

The veins of the Chandra valley traverse the gneiss in different directions, and in some places those *transverse* to the foliation (Fig. 1. Pl. II.) are reduplicated in a very remarkable manner, while those parallel to it (*b*) are quite free from contortion. These appearances at once suggest great pressure and squeezing in a direction more or less perpendicular to the foliation, and although the hypothesis is not without difficulties, the reduplications must apparently be accounted for in this manner. The veins must have been intruded either in their present form, or else comparatively straight. In the former case it is necessary to suppose the gneiss previously traversed by numerous fissures, or at least lines of weakness, of this peculiar reduplicated form, but it seems quite impossible to imagine any cause by which such could have been produced. If the veins then were not intruded in their present form, they *could* only have obtained it by subsequent pressure. It is observable that they are generally thickened at the bends (Fig. 1*a*, Pl. II.); an evident result of such force, which would tend to squeeze the veins thinner where perpendicular to its direction; and where parallel to it (*bb*) to thicken them by lateral expansion. The veins lying perpendicular to the direction of pressure would of course be liable to no contortion.

Fig. 1.

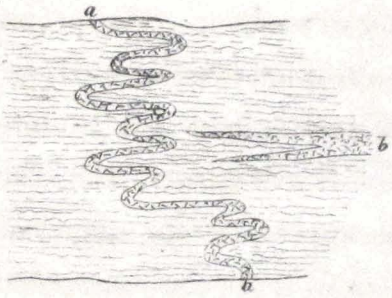

Fig. 1a.

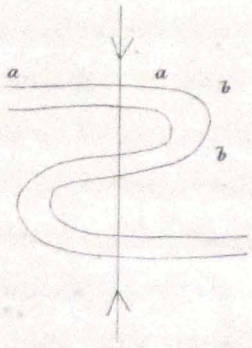

Fig. 2.

The shaded portion is Quartz.

black " " Schorl.

ON TRANSFER PAPER BY SOBHAN SUKSH. LITH: BY H.M. SMITH. SURV: GENL'S OFFICE CALCUTTA. JULY 1865.

Orthoclase.—From the porphyritic gneiss of the Jubburscesa Pass north of Lake Kiagr. It occurs through the rock in masses several inches diameter, but well formed crystals seldom exceed 2 or 3 inches in length (p. 127).

Staurotide occurs in small crystals, and sparingly, in the garnetiferous talc schists between Gaora and Serahan.

Kyanite.—From the gneiss above Yangpa. For some miles beyond this village towards the Bhabeh Pass, kyanite constitutes a regular ingredient of the gneiss in some parts of limited extent, being sometimes associated with small garnets. The kyanite occurs in the ordinary light-blue bladed prisms; rarely white and fibrous.

Tourmaline is found abundantly in the granite veins at Wangtu bridge, besides being diffused less freely through the gneiss itself. Indeed in many parts of the hills tourmaline may be regarded as a constituent of the gneiss rather than as an accidental mineral. It occurs in the gneiss north-east of Shalkar and of the Chandra valley. I have never observed any other variety, however, than ordinary schorl. Many of the prisms from Wangtu contain an admixture of quartz arranged more or less symmetrically. In these there is usually a central nucleus of pure tourmaline, around which are arranged alternate plates of tourmaline and quartz in planes radiating from the centre of the crystal. An example of this structure, which seems similar to that by which the foreign matter in chiastolite and some other minerals acquires a symmetrical arrangement, is shown in Fig. 2. Pl. II. (natural size).

The granite veins of the Chandra valley also contain a large amount of tourmaline. It occurs chiefly in the albite, even when quartz forms a prominent ingredient of the vein, which is not common. It is usually met with in long three-sided prisms, the sides often curved, or flat with bevelled angles. The termination is commonly a plain three-sided pyramid. The prisms are very commonly arranged in one direction, lying nearly parallel to each other, and this direction is perpendicular

to the sides of the vein. The crystals are larger and more abundant near the sides than in the centre. I observed in one or two places pseudomorphs of mica after tourmaline, one portion of a prism being sometimes unaltered, while the remainder was completely changed to this mineral, the plates lying parallel to the length of the prism.

Talc.—Between Rampur and Gaora the talcose schist (p. 11) contains occasional bands of very pure white quartzite, between the beds of which white and greenish talc often occurs in lenticular seams from 1 to 3 inches thick.

Serpentine.—Serpentine rock is associated with chlorite schists in the lower part of the Puga valley and in the Hanle valley below the monastery, the beds being the same in both cases. The ordinary rock is very dark green and massive, and is traversed by thin seams of a finer variety, which is frequently foliated and sometimes of a bright yellowish green color.*

Gypsum.—(*a*)—From the hot springs at Changrizang (p.158). (*b*)—From a deposit on the hill side above these springs (p. 158). (*c*)—Selenite from breccia near Shalkar (p. 156). (*d*)—From the sulphur mines at Puga (p. 163).

Alum.—(*a*)—From the sulphur mines at Puga (p. 163). (*b*)—From near Simla (p. 166).

Epsomite.—From lower Spiti (p. 160).

Borax.—From the borax grounds at Puga (p. 163).

Calcite.—From the limestone of Jatog near Simla, where it occurs in veins through the rock, and is used for making lime. Similar veins traverse the limestone of the Krol.

Spathic Iron.—From Bara Shigri (p. 165).

Arragonite—From lower Spiti (p. 158).

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* Besides the minerals previously mentioned as occurring in the serpentine, thin seams of a white carbonate sometimes fill the joint-cracks, not improbably *magnesite*; but the specimens were lost before an opportunity of examining them occurred.