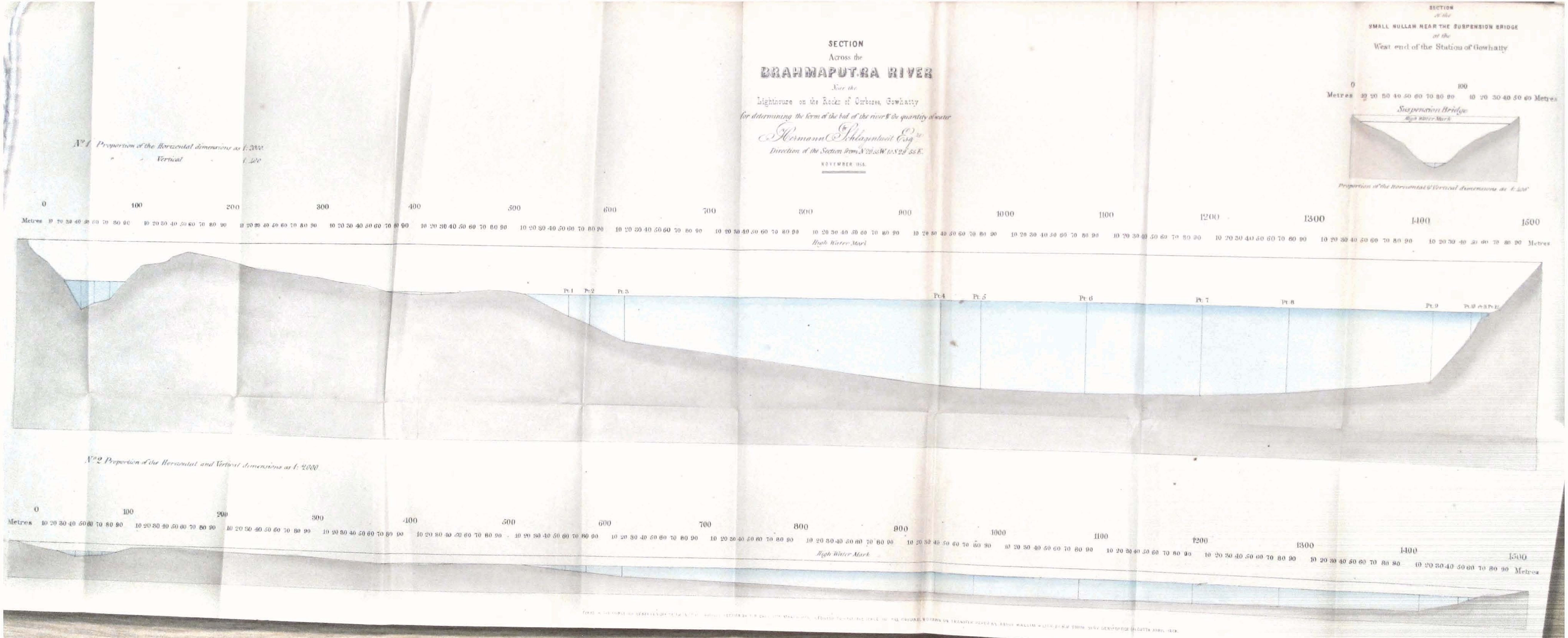


SECTION
Across the
BRAHMAPUT.RA RIVER
Near the
Lighthouse on the Rocks of Oorbosea, Gowhatty
for determining the form of the bed of the river & the quantity of water
by
Hermann Schlagintweit Esq.re
Direction of the Section from N 29 55 W to S 29 55 E.
NOVEMBER 1855.
SECTION
of the
SMALL NULLAH NEAR THE SUSPENSION BRIDGE
at the
West end of the Station of Gowhatty
Suspension Bridge
High Water Mark
Proportion of the Horizontal & Vertical dimensions as 1:400
N.o 1 Proportion of the Horizontal dimensions as 1:2000
" " Vertical " 1:200
High Water Mark
Pt. 1
Pt. 2
Pt. 3
Pt. 4
Pt. 5
Pt. 6
Pt. 7
Pt. 8
Pt. 9
Metres
N.o 2 Proportion of the Horizontal and Vertical dimensions as 1:2000
High Water Mark
Metres

JOURNAL

OF THE

ASIATIC SOCIETY.

No. I.—1856.

Report on the progress of the Magnetic Survey and the researches connected with it in Sikkim, the Khosia Hills and Assam, April to December, 1855.—*By* HERMANN SCHLAGINTWEIT, *Esq.*

From H. SCHLAGINTWEIT *in charge of the Magnetic Survey of India.*

To Sir JAMES MELVILL, K. C. B. *Secretary to the Court of Directors of the Honorable East India Company, India House, London.*

Gowhatty, December 19*th*, 1855.

SIR,

I have the honour to present you a report of my proceedings, in that part of the Magnetic Survey of India which has been entrusted to me, during the period from March to December.

The report contains, besides an abstract of the chief results, the routes we have followed up to the present date.

We are spending the present winter months in Central Assam and along the Bhootan frontier, from hence I intend to proceed to Calcutta, in order to despatch the books of observations, plans, and drawings, as well as the collections of geology and natural history, to the India House.

From Calcutta I intend, after my plans have been presented as before in full detail to the Government of India, to proceed through Bengal to the western parts of the Himalayas.

I am particularly happy to mention the valuable assistance which I have received in every way from the Government of India.

I have the honour to be,

Sir,

Your most obedient servant,

HERMANN SCHLAGINTWEIT.

1.—*Routes and Geographical Remarks.*

I left Calcutta, April 5th, proceeding viâ Kishnagur, Dinagepore and Tytaliah, to British Sikkim. My draftsman, Abdool Cawder, went the same way, keeping one day's dawk distance in order to make corresponding barometric and other observations.

The assistant, Mr. Adams, went by the steamer to Caragola Ghat and viâ Purneah to Darjiling.

After a short stay in Darjiling and its environs, we proceeded up to the ridge, which branches off from the central mass of Kunchinjinga, and extends in a southerly direction, near the southern borders of the Sikkim Himalaya. Previous official propositions to the Sikkim Rájáh for permission to travel in his dominions were perfectly unsuccessful, though Dr. Campbell, Superintendent of Darjiling, most obligingly and with true scientific interest tried every way to forward my plans.*

The range extending from Tonglo over Chundunangee, Phulloot, Gosah, Singalelah to the mass of Kunchinjinga, allowed me not only to make a very complete set of comparative magnetic and physical observations at different heights, but these peaks commanded at the same time one of the most splendid views of the snowy peaks of the Eastern Himalaya, extending 20° East from Chumalari and 30° West from Kunchinjinga.

From the different points of the Singalelah range the height and position of the snowy peaks were most carefully measured with an

* During all the time of my operations in Sikkim, I enjoyed Dr. Campbell's as well as Mr. Hodgson's precious and unremitting assistance; I take advantage, with particular pleasure, of this occasion, to return my best thanks to both these gentlemen.

It is scarcely necessary to add how much I was assisted by Dr. Hooker's previous researches in this part of the Himalayas.

Ertel's universal instrument and a theodolite by Troughton and Simms.

The detail of these measurements has been combined with drawings, in which a given angular value was made equal to a unit of linear measure; in the coloured drawings of Tonglo and Phulloot one millemeter is equal to five minutes, and though by this scale the full panorama of 360° extended to a length of 4.2 meters, it allowed me, at the same time, to enter with full detail into the topographical structure of the district.*

I intended to proceed from Phulloot along the ridge, forming from that place the boundary between Nepal and the Rájáh of Sikkim's territories, over the summits as far as possible to the central groups, but we had been observed by the Nepalese (our fires during the night being seen) and there came up first a few Nepalese sepoys, and then a native officer with twenty sepoys, sent by Karak Bahadoor, whose corps was stationed near the Wallanchoon Pass, on the frontier of Thibet and Nepal. They at first seemed not disinclined to allow at least a limited progress, but soon after leaving Phulloot we were surprised by a man, who had evidently waited some days for our passing, who brought fresh orders for the sepoys, who had come up and were now accompanying us, absolutely forbidding them to allow us to go on.

After repeated negotiations, we succeeded in getting a few miles further, to the Chungtaboo mountain, where we were obliged to return, all supplies being denied us, and some of our coolies, who were Nepalese, being threatened that they would be made prisoners.

I returned to Darjiling after an absence of seven weeks and continued my stay in British Sikkim till the 15th August, occupied with another series of magnetic observations and in completing the materials for a map of equi-distant horizontal contour lines for British Sikkim.

* The drawings of the same range of mountains having been made from different points of known position, they form pictures complimentary to each other, like stereoscopic pictures, allowing me to lay down roughly in a map many more points, if required, than could be fixed by triangulation.

The number of drawings in Sikkim now deposited in the Surveyor General's Office is 100 to 120.

This map, in the scale of three inches to two miles, proportion 1 : 42240, was sent to Capt. Thuillier, Surveyor General's Office, Calcutta, where, through the kind assistance of Capt. Thuillier, copies are now being made which will be added to the next report.

We chiefly used a portable levelling instrument, consisting of a divided wheel and a diopter for tracing the level lines from 500 ft. to 500 ft. vertical distance; with these measurments were combined the determination of the inclinations of slopes by a very sensible Clinometer.

As the latter process gives very material assistance in cases where every point is not accessible (from want of roads as well as particularly from the luxuriant vegetation), I may mention in a few words how we proceeded to deduce from the inclinations the form of the lines required. The horizontal projection (P) of a unit of vertical height [500 ft. in the present case] varies with the inclination (I) of the surface, being the cotangent of the angle of inclination multiplied by the height taken as the standard (P = cot. I. × 500.)

Beginning therefore at a point whose height was measured and coincided with the full multiple of 500 ft., the projection in the map of the next point 500 ft. higher can be deduced from the formula above mentioned.

We calculated a table containing, in inches and its decimal fractions from degree to degree, the values of P reduced to the proportion of 1 : 42240 of which I give a few numbers as an example.

Angle of declivity. degrees.	Log cot.	Horizontal distance of two contour lines in the plan, inches.
0	∞	∞
10	0.7537	0.806
20	0.4389	0.390
30	0.2386	0.203
40	0.0762	0.169
50	9.9238	0.119

The points with which the steps from 500 ft. to 500 ft. coincided being thus found on the different slopes, their combination gives the equi-distant contour lines as an immediate result.

We left Darjiling August 19th to go by boat to the foot of the

Khosia hills. I followed the course of the Mahanuddy, Ganges, Megna, and Soormah rivers, whilst my draftsman went by the Teesta in order to make a plan of the river.*

We arrived at Sylhet September 23rd, and at Cherrapunji Sept. 29th.

After visiting the different places of particular geological interest near the Southern slope of the Khosia hills, and taking a series of angles to determine the positions of spurs descending from the plateau of Jynteah,* we passed through the interior of the Khosia hills and descended into the valley of the Brahmaputra at Gowhatty. As the conditions were here particularly favourable for calculating the discharge of water in the Brahmaputra, the river passing through a channel very well defined and pretty regular, we tried to determine its amount.

I found, per second,

318,200 cubic feet during the time of low water.

894,700 cubic feet during the time of high water.

A detailed account of the operations connected with this determination is given in the latter part of my report.†

We are now visiting the Northern part of central Assam near the Bhootan frontier, the Assistant, Mr. Adams and the draftsman, Abdool, are on their way to Jypore to see the coal and lime formation, at Namding. Their directions are to go from thence by the Boree Dihing and Noh Dihing to Sudeiya, and thence to Gowhatty.

II.—*Magnetic Observations.*

At Darjiling a complete set of magnetic observations was made immediately after our arrival in Sikkim from the 15th to 17th of April, and a second series after our return from the Nepalese frontier at the end of July ; on the latter occasion three little houses of bamboo were built in order to protect the instruments for comparative observations on the daily variations.

2. At Tonglo complete observations from the 12th to 15th of May.

* This plan will also be added to the next report, it is now in the hands of Capt Thuillier, with the plan before mentioned.

† A section of the river 1 : 1000 and a plan 1 : 5000 added to the report.

3. At Phulloot [11,900 ft.] besides the determination of the declination, absolute intensity (by vibration and deflection), and dip, the daily variations of these elements were observed during a succession of five days.

4. For estimating the influence of height on the intensity of magnetism more directly, the passage of the little Rungeet, which lies between Phulloot and Darjiling, and which we reached a few days after leaving Phulloot, was particularly favourable, and careful observations of the deflection were made.

6. In order to compare the Himalayan station with the plains, a set of observations was made at Beriadangee, near Kissengunj on the shore of the Mahanuddy, and only sixty-six miles distant from the foot of the mountains in a direct line.

7. Rampore Bauleah—dip and vibration ; the cloudy state of the weather by day and night prevented the determination of the declination.*

8. Cherrapunji complete observations.

9. Gowhatty * *

In the following, I give an abridged account of some results of these observations :

The calculations of the absolute value of these elements depend as well upon the change in the magnetism of the magnets employed, as upon the regular changes of terrestial magnetism, corresponding to the time of observation.

The latter element must be deduced hereafter from the observatories of Madras and Bombay ; in reference to the magnets, all care has been taken to prevent irregular changes of magnetism, by a most careful transport, and by keeping a pair in one box (in opposite corners) the poles being in opposite directions.

The declination in Sikkim varied between 3° 9′ and 3°15′ for the different places of observation.

At Cherrapunji the declination was West, 2° 10′, a very unexpected result, probably connected with the amount of magnetic iron in the central parts of the Khosia hills, the sandstones of the plateau

* I was assisted here by Mr. Herschel, Mr. Adams being laid up with remitting fever.

No. 3

PLAN OF THE SECTION

ACROSS

THE RIVER BRAHMAPUTRA

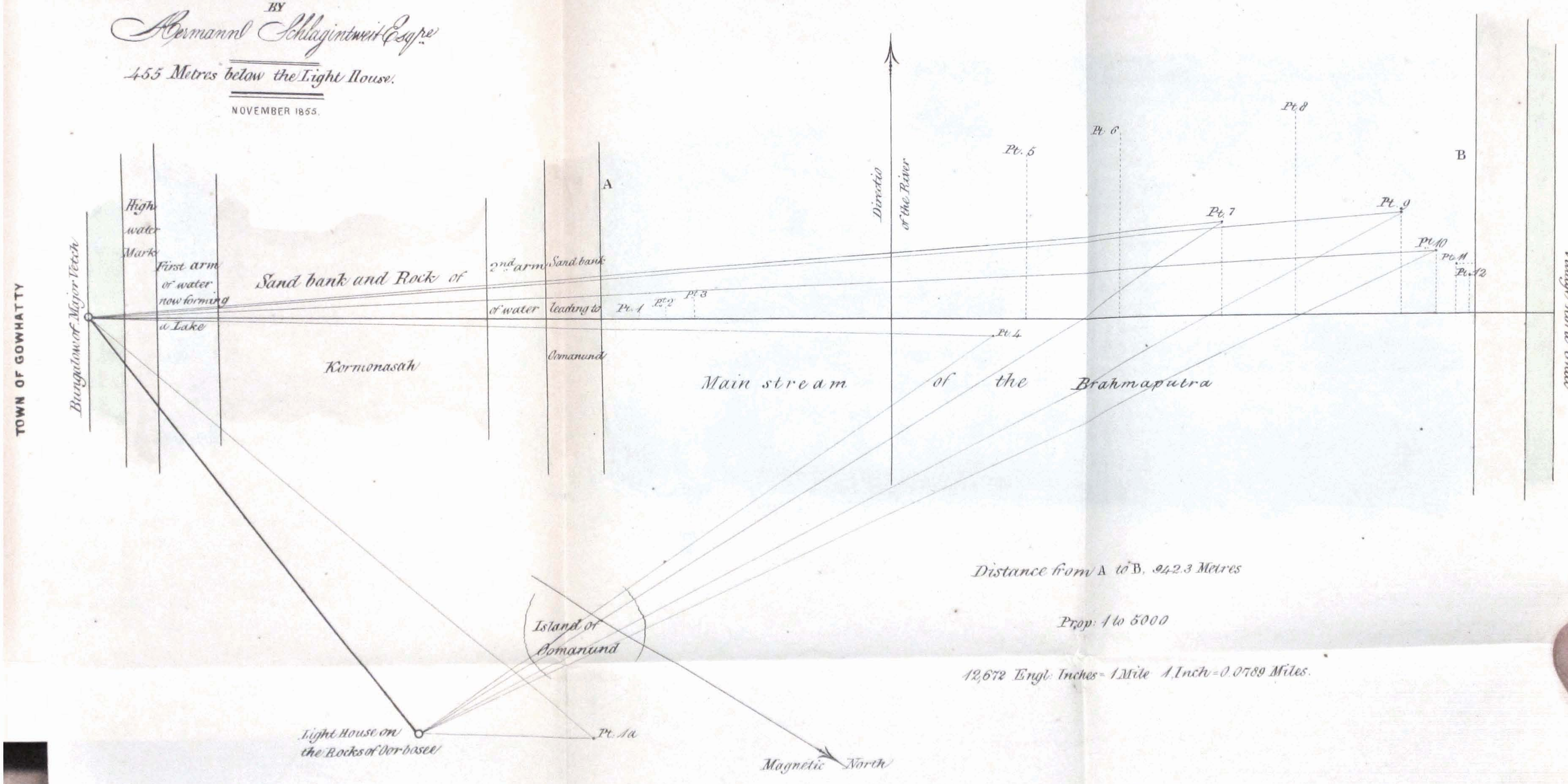
near Gowhatty

BY

Hermann Schlagintweit Esqre.

455 Metres below the Light House.

NOVEMBER 1855.



COPIED IN THE SURVR GENLS OFFICE FROM THE ORIGINAL PLAN BY GHOLAM UKBUR 13TH MARCH 1856. ON TRANSFER PAPER BY ABDUL HALEEM AND LITH: BY H. M. SMITH SURV: GENLS OFFICE CALCUTTA APRIL 1856.

of Cherra, as well as the slates of Myrung, showing no trace of magnetism, even when pieces were brought nearly in contact with the dip needle, as well as with the horizontal magnet in the deflection apparatus.

At Gowhatty the declination was found to be 1° 41′ E.

The horizontal intensity of magnetism was found decidedly to decrease with the height, as resulting particularly from the observations on the little Rungeet, and at the summit of Phulloot, with a difference of level exceeding 10,000 feet. Before giving the amount of decrease in numbers, I wish to compare with my own the corresponding observations made by my brothers in the Western Himalayas.

The results of the determination of the dip also tend to show a decrease of the vertical force of magnetism.

I had at

Darjiling, April 19th, ...	36° 28·985.
July 30th, ...	36° 31·160.
Tonglo 10,000 ft. May 12th, ...	36° 22·04.

Phulloot, [the difference in latitude making the dip greater.]

June 9th, ...	36° 46·875.

At the other stations the dip was the following:—

Beriadangee, Aug. 17th, ...	35° 11·595.
Rampore Bauleah, August 28th, ...	30° 57·75.
Cherra, October 23rd, ...	33° 34·26.
Gowhatty, December 10th, ...	35° 18·73.

Together with the magnetic observations, the meteorological elements, pressure, temperature, and moisture of the atmosphere, and the direction of the wind, were minutely observed and determinations of latitude and longitude combined.

III.—*Meteorology.*

A set of meteorological observations embracing the temperature of the air, the moisture, the pressure of the atmosphere, direction of the wind, and the temperature of the ground at different depths, had been made with great regularity in every place we passed through or where we made a stay.

I add to this report the hourly means of a set of observations made in localities of particular interest on account of their height, Tonglo exceeding 10,000 ft., Phulloot nearly reaching 12,000 ft.

The thermometer readings in the following tables are corrected for the errors of the instruments, which had been most carefully ascertained before our departure from Europe at the Kew Observatory and examined during our stay in India every three or four months.

The readings of the barometer are reduced to the freezing point.

The instruments for determining the temperature of the ground were corrected of their index errors and also reduced to the true temperature of the stratum in which the bulb of the instrument stood, a correction instrument, containing only a capillary column of mercury without a bulb, being immersed in the same stratum.

In the following tables the variation is given for every full hour. The direct observations included the time from 5 A. M. to 10 P. M. Minima and maxima were also registered.*

These observations were projected on a paper covered with square millimeters, and the hourly changes for the hours without observations were read off from the curves traced out for every day.

At Tonglo I left an observer after our departure, and the observations have thus been continued there from May to August without interruption.

* Sometimes observations were made, but not so regularly, at different hours of the night.

I.

Temperature of the Air, Tonglo, from May 10th to May 16th inclusive.

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
	Hours.						A. M.					
May 10 to 16.	6.75	6.87	6.85	6.78	6.75	6.92	7.91	9.03	9.83	10.61	10.81	11.83

	N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
	Hours.								P. M.				
	12.17	12.07	11.95	10.18	10.52	9.42	8.42	7.83	7.87	7.45	7.32	7.28	8.89

Phulloot, from May 20th to June 12th inclusive.

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
	Hours.						A. M.					
May 20th to May 26th.	6.33	6.10	5.85	5.67	5.58	5.34	6.00	6.88	8.18	9.54	10.54	11.25
May 27th to June 1st.	6.05	5.93	5.82	5.89	5.80	5.93	6.63	7.48	8.42	9.18	10.00	10.88
June 4th to June 12th,	6.95	6.72	6.64	6.57	6.49	7.07	8.58	8.54	10.65	10.74	10.31	10.91

	N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
	Hours.						P. M.						
	11.28	11.17	10.54	9.60	9.03	8.60	8.17	7.83	7.48	7.14	6.74	6.59	7.93
	11.62	11.60	10.31	9.64	9.06	8.50	7.84	7.28	6.92	6.70	6.36	6.18	7.91
	10.41	10.31	10.51	10.11	9.71	9.45	8.62	8.12	7.82	7.54	7.30	7.08	8.63

NOTE. At the summit of Tonglo the observations on the temperature of the air, and on the moisture, on the temperature of surface of the ground, etc. had been continued by an observer left there till to our departure from Sikkim in August.

II.

Temperature of the ground, Tonglo, from May 10th to May 16th, inclusive, 1855.

Surface.

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 10 to 16.	8.32	8.02	7.78	7.65	7.58	7.88	11.28	11.63	13.05	14.17	14.80	15.32

	N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
	15.73	16.03	16.05	15.08	14 25	13.00	11.10	10.28	9.73	9.28	8.93	8.60	11.06

0.3 *Meters below the Surface.*

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 10 to 16.	10.82	10.82	10.72	10.78	10.78	10.75	10.73	10.73	10.77	10.90	10.90	10.98

	N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
	10.88	10.84	10.82	10.84	10.84	10.90	10.87	10.85	10.85	10.83	10.83	10.82	10.82

1.0 *Meter below the Surface.*

Means from May 11 to 16.	M. N.	1	2	3	4	5	6	7	8	9	10	11
	8.80	8.78	8.78	8.78	8.78	8.78	8.76	8.76	8.77	8.77	8.73	8.77

	N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
	8.77	8.76	8.76	8.76	8.76	8.78	8.74	8.78	8.78	8.78	8.78	8.78	8.78

Temperature of the ground, Phulloot, from May 20th to June 12th, inclusive.

Surface.

Means	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 20 to 26.	7.77	7.10	6.35	5.63	5.03	4 97	5.54	7.59	9.71	12.80	14.91	15.76
May 27 to 31.	8.68	8.36	8.06	7.84	7.80	7.98	8.72	9.62	11.26	12.86	14.16	14.94
June 3 to 9.	8.18	8.02	7.87	7.82	7 82	8.08	7.32	15.60	12.70	13.58	13.63	14.38
June 10 to 12.	8.67	8.40	8.10	7.90	7.87	8.07	8.60	10.50	12.30	14.75	14.50	15.55

	No.	1	2	3	4	5	6	7	8	9	10	11	General mean.
	16.21	16.30	15.43	14.63	13.77	12.76	11.83	11.07	10.36	9.96	9.00	8.41	10.54
	15.80	16.00	15.34	14.58	13.74	12.00	11.18	10.68	10.20	9.75	9.40	9.12	11.17
	13.60	14.55	15.72	15.37	14.19	13.30	11.34	11.61	9.39	6.23	8.46	8.33	10.71
	16.00	15.15	15.50	14.95	12.75	12.25	11.85	11.40	10.80	10.35	9.95	9.60	11.49

0.3 *Meters below the Surface.*

Means	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 20 to 26.	7.05	7.05	7.01	6.98	6.93	6.88	6.93	6.60	6.59	6.63	6.70	6.73
May 27 to June 1 ..	8.65	8.65	8.65	8.63	8.62	8.60	8.60	8.60	8.60	8.54	8.54	8.56
June 3 to 11.	9.40	9.37	9.37	9 36	9.35	9.34	9.34	9.3	9.36	9.38	9.38	9.41

N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
6.77	6.79	6.81	6 86	6.96	7.08	7.14	7.16	7.16	7.16	7.14	7.16	6.93
8.65	8.68	8.74	8.76	8.78	8.84	8.84	8.86	8.84	8.84	8.82	8.84	8.70
9.42	9.44	9.47	9.50	9.54	9.51	9.45	9.45	9.44	9.42	9.41	9.41	9.41

1 *Meter below the Surface.*

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 20 to 26.	4.60	4.60	4.61	4.61	4.61	4.62	4.62	4.62	4.62	4.62	4.62	4.64
May 27 to June 1.	5.70	5.72	5.72	5.72	5.72	5.72	5.72	5.72	5.72	5.62	5.66	5 66
June 3 to 11.	6.91	6.92	6.92	6.94	6.95	6.95	6.95	6.95	6.95	6.94	6.94	6.94

N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
4.64	4.64	4.64	4.64	4.64	4.67	4.70	4.71	4.71	4.71	4.72	4.72	4.65
5.66	5.66	5.66	5.66	5.68	5.72	5.72	5.74	5.74	5.74	5.76	5.76	5.70
6.88	6.89	6.89	6 90	6.92	6.93	6.94	6.94	6.97	6.97	6.97	6.97	6.93

III.

Daily variation of the Barometer—Millimeters reduced to 0° C=32° F., Tonglo, from May 10th to May 16th, inclusive.

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 10 to 16.	528.35	528.39	528.41	528.41	528.42	528.45	528.49	528,55	528.83	529.21	529.07	528.61

N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
528.71	528.80	527.67	527.24	526.74	527.05	527.71	527.67	527.87	528.10	528.22	528.29	528.21

Phulloot, from May 19th to June 12th inclusive.

Means from	M. N.	1	2	3	4	5	6	7	8	9	10	11
May 19 to 25, ...	496.04	496.08	496.12	496.08	496.23	496.18	496.30	496.46	496.59	496.67	496.68	496.59
May 25 to June 1.	495.94	495.95	495.97	495.99	496.03	496.13	496.67	496.17	496.32	496.69	496.81	496.81
June 3 to 12.	494.59	494.58	495.56	494.55	494.54	496 53	494.83	494.99	495.25	495.35	494.92	494.82

N.	1	2	3	4	5	6	7	8	9	10	11	General mean.
496.62	496.54	495.84	495.60	495.50	495.43	494.88	495.27	495.57	495.72	495.83	495.91	496.08
496.57	496.31	496.20	495.96	495.88	495.85	495.78	495.78	495.83	495.91	495.95	495.97	496.12
494.96	494.64	494.33	494.13	494.05	494.00	494.08	494.07	494.47	494.54	494.79	494.81	494.67

In the following resume I will try to collect, in the form of an extract from our journals, some meteorological phenomena which seemed to me particularly interesting, either in their more general character or from peculiarities characteristic of the regions explored.

Decrease and variation of the temperature of the air.

Comparing the Sikkim Himalaya in general with the plains, it is very manifest that the law of decrease of temperature for the annual and monthly means, as particularly for the extremes of single days, is a very different one from the plains to the range of mountains not exceeding 6000 or 7000 feet, and not very distant from the plains—and from these mountains to the higher parts of the central Himalayas. In the first case the decrease is much more rapid than in the second.

The temperature also of the lower part of the hills in the neighbourhood of the plains is frequently affected by the fog, which rapidly ascends along the slopes, and does not change the temperature of the air confined between the vesicles of vapour at a rate corresponding to the variation of their height.

A similar difference in the laws of decrease of temperature is also clearly observable in the *Khosia hills*, though on a smaller scale; their steep flanks facing the south, and the gentle elevations of the ridges based on the plateaux succeeding in the interior, present a configuration particularly adapted to show such modifications. In *Assam*, we got a very valuable set of meteorological observations communicated to us through the kindness of Col. Jenkins, which, combined and reduced by our own observations, will allow us to trace the thermic lines with great detail.

The temperature of the ground, of rivers, and of springs, has been always carefully observed.

I add, as an interesting object for comparison with the preceding tables, some numbers obtained in Gowhatty, Central Assam, the instrument being employed on ground covered with short grass.

Gowhatty, Dec. 1855.		Absolute Extremes. max.	min.
Surface of the ground, ...	6 A. M.	20.4	16.2
	10 A. M.	22.0	18.3
	2 P. M.	26.4	23.4
	6 P. M.	22.4	18.5
At 0.3 meters, (11.9 *inches*) below the surface,	6 A. M.	23.5	19.2
	10 A. M.	23.4	19.3
	2 P. M.	24.8	20.1
	6 P. M.	24.5	20.4
At 1 meter, (3 *ft.* 3 *in.*) below the surface.	6 A. M.	25.9	23.0
	10 A. M.	25.9	23.0
	2 P. M.	26.5	23.0
	6 P. M.	26.0	23.0

The temperature of the Brahmaputra near Gowhatty had a daily variation of 1° 6 between 18.0 and 16.4.

The height corresponding to a decrease in the temperature of springs of 1° C. is larger, the decrease is less rapid, in comparing Assam with the Khosia hills, than in comparing Sikkim with the plains of Bengal, in the latter case the corresponding height varied between 700 and 760 feet English.

The snow line could be very well measured and its variation ascertained during our stay on the Singalelah ridge, though we were prevented from proceeding ourselves to the foot of the snow.

We found a decided difference between its annual variation on the isolated peaks in the spurs of southern direction and on the flanks of the central parts. In the first case, the snow line goes steadily up till the beginning of the rains, and shows the great periodical oscillations, its maximum being attained near the middle of July. In the inner parts, much less accessible to the tropical rains, the maximum of snow line coincides with the end of August. In a lateral valley of Phulloot, a snow-bed was found in the beginning of June, but not lasting.*

* *Moisture of the atmosphere—rain, &c.* This snow, first seen by one of my shooters, was reported to me as an immense hailstone, the solid nature of the ice nearly concealing its origin; many reports of enormous hailstones, so often mentioned in the lower parts of the Himalayas, might probably be traceable to a similar origin.

Rain.—Many instances have been observed showing the quantity of rain to be sometimes of very local occurrence,* and its distribution as much modified by the configuration and topographical position of the surface receiving the rains, as by the more general laws of the movements of the atmosphere.

Places on a steep declivity facing large plains are particularly exposed to large quantities of rain, which exceeds, for instance, in Cherra, the annual mean of 600 inches.

It is very remarkable that at Cherra the proportion between the rain during the day and the night is on an average like 2 to 3, very often exceeding that proportion, but in the months after and before the rainy season, the daily variation of the heights of the clouds is quite different, the night being generally very clear and cloudless.

The great quantity of dew in the tropics seemed an object worthy of particular attention.

We tried in the Khosia hills, and afterwards in central Assam, to determine the quantity of dew; the details of one series of experiments are given in the following pages. I add that the absolute quantity is much inferior to what the first appearance of the substances exposed and the size of the drops made us expect, but a closer inspection explains it very well, by the distances of the drops from each other; a second experiment at Cherra gave for black wool 0.4 to 0.5 millimeters, one at Gowhatty 0.6, the quantity of water in the atmosphere decreasing with the mean daily temperature more rapidly than the radiating power increases with the elevation above the plains.

Experiments for the determination of the quantity of dew and the relative radiating power of different substances.

Night at Cherrapunji from 28th to 29th of October, perfectly clear, very small low cumuli, height not exceeding 3°, disappeared after 10 P. M.

Substances exposed at 7h. 30′ P. M. Oct. 28th. Taken to the balance at 10h. 10′ A. M. Oct. 29th.

The following substances were exposed.

No. 1.—Empty paper box.

No. 2.—Black wool (very fine black colour).

* At Darjiling we had on the 12th of August, 1855, 1.15 inches in two hours, and no rain fell at the military sanatarium not two miles distant.

No. 3.—White wool (very fine white colour).

No. 4.—Black vegetable earth (as formed naturally in little concavities of the rocks, not quite black, a little reddish).

No. 5.—Quartz sand from a river, formed of decomposed sandstone rocks.

No. 6.—Short grass, imitating the natural surface in the flat of Cherra by being cut off and arranged in the box points upwards.

No. 7.—Dark grey slate from Myrung with a very uniform smooth surface.

These substances were exposed in the following way. A double stratum of light bamboo mats was spread over short grass; length of the mats 25 meters, breadth 1.4 meters. The paper boxes were disposed so as to have the greatest possible distance from each other and from the borders of the mats.

The empty paper-box, weighed at the very beginning and at the very end, was during the night protected from radiation and dew by being placed on the grass, supported by a large cake of wax, and covered by a bamboo umbrella with a stick of 0.4 meter height.

In this way we obtained the changes of weight of the paper cases, produced by absorption during the night and evaporation during the stay in the room.

Weights.

	Increase of Weights in Grammes.
1.—Empty box weighed first and last for giving a correction for the absorption of moisture by the paper, ...	0.174
2.—Black wool, ...	4.019
3.—White wool, ...	3.791
4.—Black vegetable earth, ...	2.211
5.—Quartz Sand, ...	1.965
6.—Grass, ...	2.631
7.—Dark grey Slate, ...	0.904

The change of weight in the test paper box having been 0.174 grammes, this amount is to be deducted from all the substances from No. 2 to No. 6 inclusive. Besides this, the weights of the two kinds of wool and the grass must be corrected for a small, but appreciable, quantity of moisture lost during the stay in the room before their turn came to be weighed; this quantity was ascertained by weighing them a second time, and putting the loss thus ascertained, during a given difference of time, proportional to the time which elapsed between the moment when they were brought into the room and the moment when their turn for being weighed came.

The corrections thus obtained are:—

	grammes.
For No. 2.—Black wool weighed first,	0.000
3.—White wool,	0.079
4.—Black earth,	0.012
5.—Quartz sand,	0.020
6.—Grass,	0.310

Dark grey slate could not be managed in the same way, the water being taken off by blotting. The loss may be considered as inappreciable, the water forming well defined drops not extended by capillarity over so large a surface as in the other substances.

The corrected increase of weight is therefore;—

	Difference between 1st & 2nd Weighing, grammes.	Correction for absorption grammes.	Correction for evaporation grammes.	Real increase grammes.
For No. 2.—Black wool,	4.019	— 0.174	0.000	3.845
3.—White wool,	3.791	— 0.174	+ 0.079	3.696
4.—Black earth,	2.211	— 0.174	+ 0.012	2.049
5.—Quartz sand,	1.965	— 0.174	+ 0.020	1.711
6.—Grass,	2.631	— 0.174	+ 0.310	2.767
7.—Dark grey slate,	0.904	....	....	0.904

To facilitate the conversion of the weights in vertical heights of the stratum of water deposited in the form of dew, the boxes containing the different substances, as well as the stones, were made as nearly equal to a square decimeter as we could, but the moisture allowed the boxes to extend their edges, and it was not possible to mark the stones with sufficient accuracy without a useless waste of time, the real surfaces had therefore to be ascertained after the experiments. This was done by putting them on a paper covered with square centimeters and square millimeters, tracing the upper contour line, and counting the number of little squares thus enclosed.

The surface of the slate was found 100.54 square centimeters, the boxes on an average 101.75 square centimeters, varying only between 101.70 and 101.80 square centimeters.

The temperature of the air was

	Dry bulb.	Wet bulb.
October 28th 6 P. M.	15.6	13.6
October 28th 10 P. M.	13.6	11.8
October 28th to 29th, minimum, ...	12.9	
October 29th, 6 A. M.	14.4	14.2

Therefore the gramme of dew (distilled) water may be considered equal to one cubic centimeter without any correction for the change in the volume of water by temperature. The weight of the dew deposited is, after the reduction to 100 square centimeters;—

	grammes.
For No. 2.—Black wool, ...	3.78
3.—White wool, ...	3.63
4.—Black vegetable earth, ...	2.01
5.—Quartz sand, ...	1.68
6.—Grass, ...	2.72
7.—Dark grey slate, ...	0.90

Which gives the following thickness of the deposited stratum of water in millimeters and decimals of millimeters and in decimals of the English line (.1 inch);—

	M. M.	Lines.
For No. 2.—Black wool, ...	0.38	0.150
3.—White wool, ...	0.36	0.142
4.—Black vegetable earth, ...	0.20	0.079
5.—Quartz sand, ...	0.17	0.067
6.—Grass, ...	0.27	0.107
7.—Dark grey slate, ...	0.09	0.035

The radiating power may be considered as proportional to the quantity of water deposited. Making the quantity deposited on the black wool 1000, we get the following numbers corresponding to the different radiating powers.

Black wool, ...	1000
White wool, ...	980

Black vegetable earth,	527
Quartz sand,	447
Grass,	713
Dark grey slate,	233

Winds.

As an observation of a more general nature, I may mention that in Sikkim North winds are scarcely ever observed at heights below 10,000 feet, the large central masses protecting at a remarkable distance the lower ranges to the South of them.

In the valley of the Brahmaputra a regular daily variation takes place, particularly in the cold season.

During the day East and North-East winds follow the main direction of the valley, in the night South winds descend (which are the prevailing winds in the Naga, Khosia, and Garrow mountain ranges) into the valley of the Brahmaputra, after the ascending current has ceased. The Southerly wind does not follow immediately after sunset, but much later, from 9 to 10 P. M. This discordance in time seems to show that this phenomenon is caused to a great extent by the cessation of the ascending current in the lower part of the course of the Brahmaputra, where, during the day, an ascendant current is originated over a much larger surface. The daily variation of the barometer is decidedly affected by these changes in the currents of the air.

Composition of the atmosphere.

1.—Experiments have been made about the quantity of carbonic acid contained in the atmosphere, which increases decidedly at great heights and shows remarkably great variations in regions accessible to clouds rapidly ascending from the plains.

2.—Iodized papers (got directly from Prof. Schonbein) were regularly used for getting the measurement of ozon. At Darjiling, Calcutta, and Gowhatty continuous observations were made. In the plains, particularly in jheels, we found the colouration of the paper (the number increasing with the increase of ozon) to be 1 to 1.5;

at Darjiling.. June, day 4.5 night 7.1.
July „ 3.3 „ 4.8.

At heights of from 10,000 to 12,000 feet, we got nearly always 10 (the last number of the scale) if the papers were exposed twelve hours; this allowed us to take a shorter time of exposition and to shew the variation at intervals of 3 hours during the day.

Electricity.

The most violent electric discharges take place immediately before the rains or at their first beginning.

In May I found the electricity on isolated peaks of 10,000 to 12,000 feet, in clear days, five times greater than in the plains.

Optical phenomena of the atmosphere.

The plains, as well as the mountains of Sikkim offered a great variety of interesting optical phenomena, of which the following may be mentioned in a few words.

The blue colour of the sky is in the plains of India much darker than in higher (Northern or Southern) latitudes, but the darkness of the sky does not increase with the height in the same ratio as in Europe. At heights of 10,000 to 12,000 feet, the absolute brightness of the sky is even greater than at the same height in Europe between 45° and 47° of North latitude.

The highest temperature we observed on a black bulb thermometer lying on black wool was 74° C. = 165° Fht, July, Darjiling, 7,200 ft. English.

During our stay at a greater height, we had never an entirely clear insolation after 11½ A. M.

The second colouration of the snow after sunset had not been hitherto observed in tropical climates (see Humboldt's Cosmos, vol. IV).

We had some difficulty in observing this phenomenon, since at sunset it is generally very foggy in Sikkim; but on two occasions, particularly June 2nd from Phulloot, it was as plainly visible and as well defined as I ever saw it in the Alps. Besides this, I was told by Dr. Campbell, that after the rainy season it is very often to be seen extending over all the snowy peaks, and visible a considerable time after sunset.

The chemical action of light, determined as formerly described in our "new researches in Alps," was found in maximo to be number

58 of a coloured scale in the plains, and number 30 on Phulloot, decreasing consequently with elevation.

From Phulloot, a particular modification in the transparency of the air was observed June 4th. A few minutes after sunrise the shadow of the mountain was seen as plainly as possible, and nevertheless all the objects in the same direction were visible, only a little less distinct, through it, the fine haze being just thick enough to show the limits between its illuminated and shaded part, and allowing objects at the same time to be seen through it, as through a very thin curtain.

IV.—*Geological Observations.*

In Sikkim the rocks are all crystalline and metamorphic without limits so well defined as to enable me to distinguish them in a geological map; but in these districts, the direction of joints and cleavage showed many interesting relations with the form and direction of the valleys and with the inclination of the surface.

The cleavage has a predominant dip to N. 45° E. and is generally very steep, which causes not unfrequently the slopes of the mountains to be steeper, where they coincide with the direction of the surface of the stratification, than on the opposite flanks.

In the valley of the Mahanuddy, two miles below its junction with the Ratiang, a system of sandstone containing tertiary coal was examined.

The coal at this place is of very good quality, but does not reach the surface in very large masses; more of the same coal is to be seen on the left shore of the Mahanuddy.

The sandstones dipped to N. 6° E. inclination 30°; they are followed by marls, probably corresponding in age to the limestone overlying the coal in the Khosia hills.

In the Khosia hills, the valuable geological map of Mr. Oldham allowed of but few additions, and these particularly in reference to cleavages. I found one direction of the cleavage in the sandstones on the surface of the plateau of Cherra, coinciding with one system of cleavage in the gneiss at the foot of the hills; several other systems of cleavage are decidedly different in the different succession of rocks.*

* The collection of stones now sent to Calcutta contains 500 to 600 specimens.

The geological map of the Khosia hills was continued from Nuncklow to the valley of the Brahmaputra.

V.—*Remarks on some hydrographic observations.*

The velocity of the current in different streams has been frequently measured and compared with the accumulation of deposits and size of boulders, with the depth of erosion, etc.

The quantity of the discharge has been determined in the Mahanuddy, the Ganges* near Rampore Bauleah, and the Brahmaputra near Gowhatty.

The Mahanuddy immediately below its junction with the Ratiang had a discharge of 240 cubic metres per second, and near the village of Sirsee below Malda 4,500 cubic metres per second, breadth 1,073 metres. For the Brahmaputra, the detail of the observations and the results obtained are given in the following pages.

Observations on the river Brahmaputra at Gowhatty.

The form of the valley of the Brahmaputra near Gowhatty is particularly well adapted for measuring the quantity of its discharge, the bed of the river being well defined, and the mass of water occupying only one channel. Besides, the station of Gowhatty being close to the (left) shore of the river, I had the advantage of getting much valuable information about the changes of the river in different seasons from the inhabitants. I mention particularly Major Vetch and Lieut. Craster, repeating my best thanks to them.

The observations were made from November 21st to December 13th the soundings November 28th and 30th, the determination of the velocity November 29th to December 3rd.

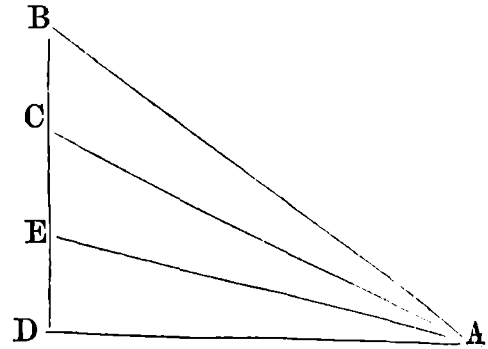
No. 1.—Breadth of the river.

The breadth of the river was ascertained by measuring a base line BE on the right shore and making a triangulation with a theodolite *reading* 10″ by the vernier.

* The observations on the Ganges have been sent to Calcutta, without the result being copied out for the report.

Angles

ABC = 76° 12′ 4″
BEA = 95° 35′ 11″
BAE = 8° 12′ 45″
= BAC + CAE
BAC = 4° 9′ 50″
CAE = 4° 2′ 55″



Length of B C = 113 meters.
" C E = 113 "
" B E = 226 "

Bearing of the line AD 150° 5′
i. e. S. 29° 55′ E. to N. 29° 55′ W.

These triangles give the following values for the real breadth, represented by the line AD.

	Meters.
Δ BAE gives AD =	1531.5
Δ BAC " " =	1531.7
Δ CAE " " =	1526.5
Mean	1529.9

This line is to be reduced by 42.9 meters, the theodolite not standing close to the high water mark on the left shore, and to be augmented by 22.3 meters on account of the instrument's position on the right shore, therefore we get as the resulting breadth from one high water mark to another, 1509 meters, 4951 feet.

Levellings in the bed of the Brahmaputra river at Gowhatty.

Distance—in metres.		Reading of levelling rod, left bank, metres.	Difference of level. Positive metres.	Difference of level. Negative metres.	
0	4.9	0.14	1.402	..	Total height of the left bank from the water mark.
4.9	9.7	0.182	1.368	..	
9.7	16.5	1.080	0.470	..	
16.5	22.22	0.747	0.803	..	
22.22	29.44	0.074	1.456	..	
29.44	34.16	0.214	1.336	..	
34.16	41.63	0.230	1.320	..	
		First arm of water.			8m. 155
41.63	106.63				

Levellings over the Karmanásáh rock.

106.63	108.06	2.107	..	0.557	
108.06	110.08	2.121	..	0.571	Ascending parts. 6m. 376
110.08	118.23	2.113	..	0.563	
112.23	114.16	2.155	..	0.605	
114.16	117.88	2.137	..	0.587	
117.88	122.60	2.156	..	0.606	
122.60	140.97	2.126	..	0.576	
140.97	149.89	2.076	..	0.526	
149.89	152.11	2.160	..	0.610	
152.11	157.14	2.115	..	0.565	
157.14	170.22	2.160	..	0.610	
170.22	195.12	0.860	0.790	..	
195.12	221.82	0.331	1.219	..	

Distance—in metres.		Reading of levelling rod metres.	Difference of level. Positive metres.	Difference of level. Negative metres.	
			2.009	..	Descendingparts
221.82	241.25	0.346	1.204	..	7.761
241.25	274.96	0.869	0.681	..	The water a-
274.96	309.73	0.812	0.738	..	bove forms dur-
309.73	332.47	0.255	1.295	..	ing this season
332.47	361.17	0.450	1.100	..	a lake, the depth
361.17	380.99	0.816	0.734	..	of which does
	Second arm of water.			..	not alter so ra-
380.99	453.27	Sand bank.		..	pidly as the ri-
453.27	484.57	1.929	..	0.379	ver. Ascending parts 0.474
484.57	505.62	1.645	..	0.095	Descendg. parts 0.499.
505.62	522.07	1.051	0.499	..	..
	Large mass of water. See compass bearings.				
	Right shore from the water up to the high water mark.				Total of the ascending parts
0.	8.4	1.985	Here ends the steep bank, the slope of the following parts is 15° in an average.	0.435	rightshore9.540.
8.4	11.3	2.025		0.475	The basis of
11.3	14.22	2.011		0.461	the masonry on
14.22	16.82	2.152		0.602	which the light
16.82	19.22	2.148		0.598	house stands is
19.22	21.52	2.130		0.580	justpassed by the
21.52	22.62	2.149		0.599	highest water;
22.62	44.99	..		5.79	ht. found above water 9m. 41.

No. 3.—*Soundings.*

First some soundings were made from a small boat; the boat not being provided with an anchor the angular distance between two objects on shore for ascertaining the exact place could not be taken with sufficient accuracy.

These points correct for depth are marked with dotted lines in the *plans*.

Then another set of soundings was taken, using a larger boat with an anchor, the position of the places was ascertained by bearings to the light house and the chimney of Major Vetch's house.

Light house from Major Vetch :—

Angular height of the white column, ... 31′ 30″

metres.

Lineal height, ... 5 16

Bearing magnetic, ... N. 22° 5 E.

Resulting distance, ... 563.2 metres.

The places of the soundings and the depth found are contained in the following table and laid down in the *plan* of the Section :

No. of the place.	Distance from the shores of the main branch of the Brahmaputra. From left shore in metres.	From right shore in metres.	Distance from the line of the section in metres.	Depth in metres.
1	42.5 ⎧ measured	..	Below 15	4.5
2	65.0 ⎨ by a rope ⎩ directly.	..	„ 17.5	5.8
3	90 to 110	..	„ 28.	9.3
4	420 5	..	Above 20.1	17.1
5	450 to 470	..	Below 180.	17.3
6	..	370 to 390	„ 230	18.0
7	..	265 0	„ 102.5	17.8
8	..	170 to 195	„ 225.0	16.5
9	..	52.5	„ 111.5	14.0
10	..	15.0	„ 70.	5.0
11	..	8.0	„ 52.5	1.0
12	..	2.5	„ 40.0	0.5

NOTE.—No. A in the plan was above the island of Oommanand and a little to the right of it. Depth 12.5 metres.

No. 4.—*Velocity of the water.*

The following table contains the numbers found for the velocity of the water at different points. The velocity was ascertained, No. A for the surface by an empty pot (ghurrah), No. B for depths of 7.5 and 10.0 meters by bamboos loaded below with sacks containing sand and protected against their sinking deeper than their full length by a pot tied to the upper end, a thin and very soft rope, 100 meters long, was attached to the floaters so as to give as little resistance as possible to their progress.

Velocity of the Brahmaputra.

Points and total depth. (See plan and section.)	Velocity, meters in 1 second.			
	Surface.	Depth of 7.5 m.	Depth of 10 m.	
Pt. 1a, depth 12.5 m.	1.28	....	....	This water was stopped by the island Oommanand behind which the velocity was 0.
Pts. 1, 2, 3,....	Velocity 0, a little motion at about 30 m. from the shore, at 43 m. the vel. and depth the same as at pt. 4.			
Pt. 4 depth 17.1 m.	1.30	1.20, 1.24 } Mean 1.22	1.10, 1.08 } Mean 1.09	A very good point, full stream.
Pt. 7 depth 17.8 m.	1.42	1.30, 1.30, 1.28 } Mean 1.30	1.20, 1.23, 1.21 } Mean 1.21	Also quite regular full stream.
Pt. 9 depth 14.0 m.	1.15	1.20, 1.25 } Mean 1.22	130., 1.32 } Mean 1.31	The lower currents here are more rapid owing to a tendency of the water to flow in the deep channel indicated by sounding, No. 8.
Pts. 10, 11, 12,..	Very slow motion, protected by a spur of the Ceela hill.			

Note.—The motion becomes 0 at about 50 meters distance from the right shore.

No. 5.—*Quantity of water.*

In the present state of the river, approaching pretty nearly its minimum of water, only the surface of the section of the main stream can be taken into consideration in estimating the discharge of water, the Eastern part being formed by sand banks or still water.

The area of the section between the distance of 665 meters and 1420 meters from the left shore contains, as found by projecting it on paper where 5 square millimeters are equal to 1 meter square of the natural size,

8044 square meters.

This must be multiplied by the mean velocity.

The mean velocity lies, as an inspection of the table of velocities shows, between

1.0 and 1.2 meters per second

it can be determined more accurately by the formula

$$m = s - \sqrt{s} + 0.5,*$$

where m is the mean velocity, s the surface velocity in English inches per second, from which the meters are got by multiplying the result by .0254.

The surface velocity being 1.30, 1.42, 1.15 meters or 1.29 meters on an average, the resulting mean velocity is 1.12 meters a second.

This multiplied by 8044 the number of square meters as mentioned above gives as the *discharge of water* in 1 second of time.

9010 cubic meters = 318200 cubic English ft.

To get an approximate idea of the discharge during the greatest height of the water the following considerations may guide us.

The velocity in the main stream of the Brahmaputra during the height of the water after the rains, approximately ascertained from the rate of boats at the time of low and of high water is at least $\frac{3}{2}$ of what it is at present, a velocity, sometimes even exceeded in times of rapid rises of the river.

The increase of the section of the main stream between 665 and 1420 meters from the left shore is, as shown by the section 6750, square meters.

These multiplied by 1.68 gives an increase of water

= 11340 cubic meters.

* The bottom velocity "b," expressed by the formula b = 2 m — s becomes 0.95 meters per second.

From 1420 m. to the right shore the increase of the section is 248 square meters.

The depth being less, the velocity seems not much to exceed the present velocity of the main stream, which gives an increase of 248 × 1.12.

= 277 cubic meters.

The rest of the river to the left shore increases the section by 3270 square meters leaving out some shallow places close to the Kormonasah rock.

The velocity of this part being, particularly in the arm No. 1 of the section, very rapid is at least 1.5 meters, corresponding to a discharge per second of

4705 cubic meters.

Total increase 16320 cubic feet.

Approximate total quantity during high water,

25330 cubic meters.

or 894700 cubic ft.

JOURNAL

OF THE

ASIATIC SOCIETY.

No. II. 1856.

Report upon the Progress of the Magnetic Survey of India and of the researches connected with it in the Himalaya Mountains, from April to October, 1855.—*By* ADOLPHE SCHLAGINTWEIT *and* ROBERT SCHLAGINTWEIT.

To Captain ATKINSON,

Officiating Secretary to the Government of India,

Military Department.

SIR,

1. We have the honor to lay before Government a Report upon the progress of our researches in the Himalaya mountains during the last season; we also beg to subjoin a short account of our journey in Thibet, which may be considered as an Appendix to the Scientific Report. We should feel much obliged if Government would do us the favor to communicate the Reports, &c., to the Asiatic Society of Calcutta, for publication.

2. We beg further to communicate to you for the information of Government, that, having completed, for this season, our researches in the Himalayas and Gurhwal, we left the Himalayas on the 8th of November, after having staid three weeks at Mussoorie, to put in order our books of observation, the maps and drawings, &c. We arrived at Agra on the 20th of November, and we propose leaving on the 28th or 29th instant.

In conformity with the plans sanctioned by the Honorable Court of Directors, we propose to go down, during the present cold season, to Subulpore, Nagpore, and if possible south of it into the Madras Territory, to examine the Physical Geography and Geology of the interesting Mountain systems of Central India.

We have the honor to be, &c.
(Signed) ADOLPHE SCHLAGINTWEIT.
" ROBERT SCHLAGINTWEIT.

Agra, November 24th, 1855.

GENERAL OUTLINE OF THE ROUTE.

We left Calcutta on the 25th of March, and went by Raneegunge and Gya to Patna. It was originally intended that we should carry on our researches during the summer in the Himalayas of Nepal. But being informed at Patna, by the Resident, Major Ramsay, of the difficulties which we should find in Nepal, and of the great reluctance of the Nepalese Government to grant us permission to go to any distance from Kathmandu, we thought that the object of our scientific researches would be better advanced by our going during this season further westward to the British Provinces of Kumaon and Gurhwal.

We proceeded therefore, in accordance with verbal instructions received beforehand in Calcutta, one of us (Adolphe) by Ghazeepore, the other (Robert) along the Grand Trunk Road to Benares. After staying two days at Benares (from the 5th to the 7th of April) in order to make a set of magnetic observations, we went up, by Allahabad, Futtehghur and Bareilly to Nynee Tal, in Kumaon, where we arrived on the 15th of April, having been engaged during our journey chiefly with Geological and Meteorological observations. We remained at Nynee Tal and its environs till the 15th and 20th May. We stayed several days at Chunar and at Heriakanta, two isolated mountains in the neighbourhood, which gave us a very good opportunity of making several physical and topographical observations. One of us, (Robert) left Nynee Tal on the 15th of May, taking the route by Almora, Bagesur and Momespanee to Milum, the highest village in Johar; the other (Adolphe) went on the 20th of May to Pindaree and over the Pindaree or Trail's Pass (17,950 E. F. high) to Milum, crossing at the Pass the high snowy range of Trisoal and Nanda Devi.

During the month of June, we were both of us engaged at Milum, and at several elevated places and glaciers at some distance from it, with a series of Physical and Geological observations. We left Milum on the 6th of July and went by the Uta Dhura (17,670 E. F. high) and Kyangur (17,300 E. F.) Passes into the Thibetan Province of Gwarikhorsum; all the baggage which was not absolutely wanted being sent round by Hoti and Niti to Badrinath. After many negociations with the Lhassa Officials forming the Government of these parts of Thibet, we made it possible to go as far as the Sutlej, and afterwards as far as the Chako La Pass (17,350 E. F. high) which lies in the range separating the Sutlej from the Indus, where we arrived on the 25th of July.

We succeeded in reaching from thence, between the 26th and 28th, the valley of the Upper Indus, near Gartok, which had only once before been visited by Europeans, i. e. in 1812, by Moorcroft and Hearsay.

From two stations, one near the Indus, the other at a fine isolated peak, Gunshankoerr, (29th July, 19,640 E. F. high) not far from Chako La, we had an opportunity of taking several series of angles with a Theodolite, which will serve to lay down the Mountain systems round the origin of the Indus and North of it.

From Chako La we proceeded by Gyungal, Daba and Maugnang to the foot of the great glacier stretching out to the northward into Thibet from the high peak Ibi Gamin (called also Kametinrite), where we arrived on the 13th of August.

After having explained the merely scientific nature of our researches and made the necessary arrangements, we met with no further trouble in any way, and enjoyed throughout our journey quite a friendly intercourse with the inhabitants.

We started from this point on the 16th of August, to examine the structure and dimensions of the Ibi Gamin glaciers, with the intention also of attempting to ascend as high as possible on the flanks of the Ibi Gamin.

After encamping on the 18th of August on the highest Moraine of the Ibi Gamin glacier, at an elevation of 19,220 E. F. we succeeded, on the 19th of August, in ascending on the Northern flanks of Ibi Gamin, covered with deep snow, to a height of more than 22,200 E. F. (22,260 E. F.) calculated from Agra.

The very difficult ground, and a strong North wind, made it impossible to advance any higher on the flanks of the Ibi Gamin, whose summit is about 25,500 E. F., according to Captain R. Strachey.

We had an opportunity, during this ascent, of making several observations on the temperature, the hygrometric conditions, and the transparency and blueness of the atmosphere, and of examining on a large scale the Geological and Orographical structure of the great group of the Ibi Gamin Mountains. We may be permitted to remark, that, as far as we know, it is the grestest height in any Mountain system at which, till now, any observations of a similar kind have been made.

Encamping the next three days on different parts of the Ibi Gamin glaciers, between 17,800 to 19,000 E. F., we crossed, on the 22nd of August, a high glacier pass, leading from the Western branch of the Ibi Gamin glaciers, along the Sursutti glacier, down to the valley above Mana and Badrinath.

This pass (20,430 E. F.) is certainly one of the highest in the Himalayas; it has only once been crossed, by people from Mana, some 30 or 40 years ago.

We arrived at the village of Mana, above Badrinath, on the 24th of August. From Mana, we took two different routes, one of us, (Adolphe,) left on the 2nd September and went again into Thibet by the Mana Pass (18,365 E. F. high) for the special purpose of completing the Geological investigations on the composition of the sedimentary fossiliferous strata on the North side of the Himalayas.

He succeeded in crossing the Sutlej a second time near Toling, and, accompanied by a few mounted men, reached on the 9th of September, without being in any way molested, the high pass of Phoko La (18,700 E. F. high) lying in the ridge which separates the Sutlej from the Indus, North-West of our former station, Chako La.

He took a series of angles from this place, and went back to Toling, Tsaprang, and from thence to the village of Puling.

On the 19th of September, he returned by the Nelong Pass (18,110 E. F.) from Thibet into the Himalayas properly so called, arriving at Nelong on the upper branch of the Bhagarutti, or Western Ganges, on the 24th of September, and reaching the village Mukba, a little beyond Gangotri, on the 27th of September.

A high pass, (3rd October 17,610 E. F.) leading from Mukba to the origin of the Tonse River, offered a good opportunity for examining the very remarkable Geological structure of the high groups of the Jumnotri and Dundar peaks.

From the Tonse, he went up to Kedar Kanta (12,630 E. F.,) an isolated Mountain, commanding a very extensive view, and after staying there two days (12th and 13th of October), went down along the Jumna valley to Mussoorie, which he reached on the 18th of October.

The second of us, Robert, left Badrinath on the 7th of September, having been engaged for some days with Photographical experiments.

He went down by Tosheemath and Okimath to Kedarnath Temple, where he employed three days, (21st to 23rd September,) in examining the structure of the Kedarnath glacier and the Topography of the Mountain system between Kedarnath and Gangotri. Sending round the baggage by the ordinary road, he himself crossed over a series of passes from 11 to 12,000 feet to Salung, on the Bhagarutti River, where he arrived on the 3rd of October. These passes offered a good opportunity for the determination of the limits of vegetation in the central parts of the Himalaya for comparison with similar observations which had been previously made on the higher passes leading out to Thibet.

From the Bhagarutti he crossed over the Chaia and Bainsura Passes (15,280 E. F.) to Jumnotri, and there examined the remarkable hot-springs; the temperature of the warmest is 89° centigrade, being nearly equal to the temperature of boiling distilled water at this place (90.50° cent). He filled here, as well as at the hot springs of Badrinath, Gaurikund, Uri and Banassa, a considerable number of fine glass bottles with water, and we hope that the chemical analysis of these waters may not prove without some interest hereafter. He went down along the Jumna River to Mussoorie, where he arrived on the 21st of October.

We beg finally to state the great obligations we are under to Mr. Batten, the Commissioner, and to Captain Ramsay, the Assistant Commissioner, of Kumaon, who did every thing in their power to assist the progress of our researches in the Himalayas, and who kindly procured for us every where the men best able to give us all the necessary information about the country.

Physical Geography and Meteorology.—Magnetic Observations.

1st.—Complete Magnetic Stations have been made at—

1. Benares.
2. Nynee Tal.
3. Milum in Johar.
4. On the Sutlej near its confluence with the Gyungal River, where only the Magnetic Dip and Declination could be determined.
5. Mana in Gurhwal above Badrinath.
6. Nelong (declination only).
7. Ussila, near the origin of the Tonse River.
8. Mussoorie.

We may be excused for not entering at present into any detail of the result of the Magnetic observations themselves, since we are anxious, before giving the general results of these observations, to compare our data with the corresponding observations made by our brother, Hermann Schlagintweit, in the Himalayas of Sikkim, in the Khasia Hills, and in Assam.

The necessary calculations and reductions will, however, be completed in a short time, and we shall have the honor to submit to Government, as soon as practicable a full comparative account of the whole of these observations.

Barometric and Hypsometric observations.

2nd. We have been able to make during the whole of our journey continuous observations of the Barometer and of our delicate Hypsometers or boiling point Thermometers.

Our two Hypsometers have arrived quite safely at Mussoorie. Of the Barometers which are very difficult to carry during a long time over a mountainous country, one by Adie, of London, arrived in perfectly good order in Mussoorie. In two others, some air introduced itself; they will however, be easily boiled and put again in perfect order, in Lieut.-Colonel Waugh's office at Dehra. Two small Mountain Barometers, by Newman, with which Captain Thuillier kindly supplied us at Calcutta, were of great use to us whilst going up along the Ganges to Nynee Tal, enabling us constantly to make comparative observations with the help of our assistants, but we found that their construction was not well adapted for travelling in the Himalayas, where a considerable quantity of air soon introduced itself into the tubes.

3rd. We have determined the elevations above the sea of from 350 to 400 places, and have endeavoured as much as possible to obtain for each place not only one, but several readings of the instruments at different hours. At some stations like Nynee Tal, Chineir Peak, Laria, Kanta, Milum, Tanti Pass, the Sutlej near Gyungal, Mangnang, Mana, Kedar Kanta and Mussoorie, we have obtained a regular series of Barometric observations during several days or several weeks, we ourselves or our assistants reading the instruments hourly, or at intervals of two hours.

We may be excused for not subjoining to this Report any larger list of heights, since it would take a very considerable time to make the necessary calculations with all the accuracy and the detail which is required for exact and final results, and the great distances over which we shall have to go to complete the observations made last year, make it impossible for us to stop a long time in one place. In reference to the heights quoted in this report, we wish to state that they have been calculated from corresponding observations made at Agra and at Bareilly. The observations at Agra were made with great care in the Office of W. Muir, Esquire, Secretary to the Government of N. W. P., for those at Bareilly we are indebted to the scientific zeal of Dr. Payne. Mr. Muir obligingly transmitted to us regularly the monthly registers.

The heights thus deduced must not be considered as quite final results, since at a later period, when we have an opportunity of calculating the whole of our heights from several corresponding stations, and introduce certain corrections in reference to the exact mean temperature of the air between the higher and the lower stations (deduced from simultaneous observations at intermediate places), our present results may be altered in some degree.

Temperature of the air and of the ground.

4th. The Meteorological observations of the dry and wet bulb Thermometer, of the temperature of the ground from the surface to a depth of five or six meters, of the temperature of rivers, &c. have been regularly made in connection with the Barometric observations; a regular series of observations being made at all the stations where we halted for some time. We found that the moisture of the atmosphere considerably decreased as we advanced from the southern branches of the Himalayas northwards to the high valleys. In Thibet, the dryness of the atmosphere was constantly very great. It is also worth remark that in Thibet, during the warmest months of the year, in July and August, the temperature of the air is sometimes very warm, rising in the shade at elevations of 13,000 and 14,000 E. F. to from 22° to 25° (centigrade). The temperature of the surface of the ground exposed to the sun rises to 45° centigrade.

The *variations* of temperature are, at the same time, very great, and sudden clouds, which prevent for a time the heating of the soil by the sun, produce, after a short time, a great decrease in the temperature of the air, amounting to 10° and 12° cent. Passing clouds, sending down suddenly a light fall of rain, or more often of fine-grained snow, are also of very common occurrence, both in the Sutlej valley and on the Passes.

5th. The rainy season extends, though with much diminished force, up to the highest valleys along the southern water-shed of the Himalayas. It begins later and ends earlier than in the outer ranges, and on many days the threatening clouds travel up from the southward to the higher valleys, without producing any sensible fall of rain. The rainy season cannot be said to extend properly speaking across the Himalayas into the basin of the Sutlej. The regular succession of the dry and rainy seasons of India is unknown there, and, from very good information which we obtained, there is no month of the year which can be considered free from rain. But nevertheless the *influence* of the Indian rainy season is still felt in

Thibet. During the time of heavy rain-falls on the southern side of the Himalayas, we very often saw for several days together masses of clouds, which came from the south, hanging over the Sutlej plain. They occasionally produced rains, which fell in great quantities, but never lasted an entire day.

6th. The *winds* in the Himalayas and in Thibet during the summer months, are generally of great regularity, blowing up constantly nearly every day from the South, South-West or South-East.

(*a.*) In the upper Himalaya valleys, the wind generally sets in at from 9 hours to 10 hours A. M., its strength increasing considerably towards the evening.

(*b.*) The intensity of the wind seems to be greatest on the passes leading from Thibet into the Himalayas elevated from 17,000 to 19,000 E. F. where we experienced sometimes in the afternoon a most furious Southerly gale. In going from thence to the Southward, the intensity of the wind decreases in a very striking way, and on Kedar Kanta, and on the stations in the outer Himalayan ranges, the intensity of the wind is, comparatively speaking, very slight. This increase in the intensity of the wind on the high northern passes seems to be due to two causes—the first of them is, that the wind may in part originate in the hot valleys of the Southern Himalayas themselves; the second, and we presume the more important cause, will be that the wind produced by the great ascending current over the heated Indian plains is fast travelling Northward at a very great elevation, and only sinks down when it reaches the colder and higher chains of the central Himalayas.

In support of the latter view, we may mention that we often saw very high clouds above us moving at a great rate, whilst the wind at our own elevation had a much smaller velocity.

7th. Our observations of the temperature of *springs* and of the *ground* at various depths have shown—

(*a.*) That the temperature of springs and the temperature of the ground at depths varying from one to three meters, is, at *equal* heights, considerably higher in Thibet than in the Himalayas; the cause of this will be that, in Thibet, we have a plateau whose mean elevation is from 14,500 to 16,000 E. F., whilst the Himalayas, at the same height, offer only a series of ridges, intersected in all directions by large and deep valleys.

(*b.*) The height at which the temperature of the ground is 0° cent. or 32° Faht. seems to be along the passes which lead from the Himalayas, into Thibet, about 17,000 F. F., at this height we several times found the temperature of the ground at a depth of 2 or 3 meters to be 0° cent., and some good springs a little lower showed temperatures of only 0.2° and 0.5° cent.

8th. In the outer ranges of the Himalayas, and in the valleys between them, at elevations of about 4,000 E. F., the temperature of good springs on an average may be assumed at 18° cent., the decrease of temperature from this height to the line of zero would therefore be one degree cent. for an ascent of about 720 E. F. It seems pretty certain that the decrease of the temperature of the ground and of the springs from the foot of the Himalayas up to the line of zero is more rapid than in the Alps of Europe, where we formerly found 700 or 730 French feet for a decrease of temperature of one degree cent.

9th. We endeavoured as often as possible throughout the journey to determine the height of *the different lines of vegetation*, the height of the snow line, &c., by aid of our barometers. We found, as a general rule, that the limits of shrub vegetation, of grass, and phanerogamic plants, rise considerably higher on the Thibetan Mountains than in the Himalayas. We found that some very isolated phanerogamic plants ascend generally speaking, in these two Mountain ranges to heights of 17,800 to 18,400 E. F. ; the maximum of height, to which we saw some very few phanerogamic plants rising, was on a sunny rocky island, between the snow masses of the Ibi Gamin glacier, at an elevation of 19,800 E. F., which, if we are not mistaken, is the *greatest height* at which till now phanerogamic plants have any where been found. The line of the lower limit of snow without doubt rises higher on the Northern Thibetan side of the Himalayas than on the Southern India face of the mountains, as Humboldt maintained a long time ago.

In reference to the periodical development of vegetation, which forms an interesting element in considering the Physical Geography of a country, we may mention, amongst other results, that in Thibet, in valleys of 12,500 to 14,000 E. F. elevation, the ripening of grain (a sort of wheat) takes place at a considerably earlier period than in the valleys of the Himalayas which are situated only at heights of from 10,000 to 11,500 E. F.; the principal cause of this appears to be that, in the higher Himalayan Mountains, the great amount of snow retards vegetation in the spring, and tends after melting to cool down the temperature of the surface of the ground for some considerable time, whilst in Thibet the fall of snow in winter is never large, and, as we have been informed, it constantly melts away again some days after its fall.

Influence of height upon Man.

10th. The influence of height upon the constitution of man varies exceedingly in different individuals. It depends much on the physical strength, and the acclimatization of a few days at great elevations certainly tends very considerably to diminish its effects; but there is no doubt that this influence exists; it generally produces more or less severe headache, and difficulty of respiration, and in some instances we saw that some of our people were spitting blood; complaints of the eyes too are of frequent occurrence, produced in part by the bright light of the snow, in part by heavy winds which blow small dust into the eyes. It certainly is difficult to ascertain how much is due in these phenomena to the diminished pressure of the atmosphere, and how much to the great bodily exertion.

We had occasion ourselves to test the great effect of acclimatization; when for the first time we crossed heights of 17,500 and 18,000 E. F. we felt more or less headache, but after having crossed several others of these passes, and slept and lived on them for some days, we found ourselves quite free from any complaints at heights of 18,000 and 19,000 E. F., when, however, we ascended Ibi Gamin to a height of more than 22,000 E. F. neither we nor any one of our people escaped headache, difficulty of breathing and severe pains in the eyes.

Geography and Geology.

11th. We had with us two Theodolites, a large one minutely divided by Pistor, at Berlin, and a smaller one by Jones, which have remained in perfect order during the whole of the journey.

We made great use of them in the parts of the Himalayas North of the Snowy Range and in Thibet, and we endeavoured, by taking a series of angles from several elevated stations, to furnish materials for ascertaining the position and height of the ranges between the Sutlej and North of the Indus; the principal stations were near Milum and on the Milum Glaciers, the Sutlej near Gyungal, the Indus near Gurtok, Gunshankoerr (19,640 E. F.), on the Ibi Gamin Glacier (19,220 E. F.), on the Mana Pass (18,365 E. F.), Chako La (17,350 E. F.), and Phoko La (18,700 E. F.), the Nelong Pass 18,110 E. F.), &c.

We hope that our observations, combined with the excellent researches formerly made at other points by Captains Henry and Richard Strachey, may serve to give a pretty correct general view of the interesting geography of the large basin of the Sutlej.

11th. Our topographical maps refer more especially to the different glacier systems in the central groups of the Himalayas, several of these maps will be found in the book of drawings, &c., which we have the honor to submit to Government for inspection, together with this Report.

We think it essential to state that these maps, as they are at present, being mere *topographical* sketches made during the journey and on the ground, have, comparatively speaking, only small parts of our bearings and angles protracted upon them. They will all require revision and correction, after the final computations of our angles; we hope therefore, that these maps may not be used for publication, till we have had the opportunity of making all the necessary revisions as accurate as possible.

We must content ourselves with enumerating in a few paragraphs some of the results to which we think the geological investigation of this part of the Himalayas must lead us.

12th. The extent of the real crystalline rocks, as granite, gneiss, and true mica schists, is, comparatively speaking, much smaller in the Himalayas than has been sometimes assumed. They are strictly limited to the high central groups of this mountain system.

These groups seem to form, from a distance, one *continuous* line of high peaks, covered with snow, generally known under the name of the *Snowy Range;* but in reality, it is by no means a continuous chain of mountains, but a succession of *several* groups *separated* very often by deep valeys.

These groups do not even follow each other from East to West on one and the same line; but some of them, as, for instance, the group of Nanda Devi and Trisoal, lie very much to the South, while the next great group, that of Ibi Gamin, lies thirty or forty miles more to the Northward. There are also instances of several central groups, or at least several nearly quite independent parts of one system, lying behind each other, in making a section from South to North, so that you have in going straight to cross a series of snowy ranges.

The best examples of the latter structure with which we are acquainted at present, are the high groups of Bunderpunch and Shergeroin near Jumnotri, with the high Dundar peaks North of them, and the high mountains to the North and South of the Baspa valley in Bisser.

This arrangement of the central Himalayan groups reminded us very much of the structure of the Alps.

Altogether, indeed these central groups of the Himalayas have much resemblance to the highest parts of the European Alps, both in reference to the distribution and general form of the valleys filled with numerous glaciers, as well as with regard to the forms of mountain peaks and the character of vegetation.

But these are nearly the only parts of the Himalayas which can be compared with the Alps, the geological structure of all the rest is extremely different.

The *prevailing* rock of most of the Himalayan groups is gneiss, *passing* into mica schist. It was only in some of them, as in the Gangotri and Jumnotri groups, that we met with large and predominant masses of true granite; in some places this granite passed into the remarkable rock *protogine*, or talc granite, which composes the Mont Blanc group in the Alps.

We felt considerable interest in investigating whether the "fanlike" structure which prevails in many groups of the Alps, was also to be found in the Himalayas.* As far as we have ascertained at

* By "fanlike structure" is understood the curious phenomenon first discovered in the Alps by Saussure, that in several instances the strata or planes of foliation

present, it seems that this structure cannot be considered as very general in the Himalayas. We only found one clear example of it in the Jumnotri and Bussa group.

There we see the gray slates constantly dipping *under* the granite, which overlies them in thick masses, forming the high peaks of Bunderpanch, Shergerfoin, &c.

13th. The Feldspathic crystalline rocks of the centre, are accompanied by large masses of grey schists, which are especially developed along the Southern side of the central groups; to the Northward of them they often form only a very small band, passing into stratified azoic slates. These schists can by no means be considered as a real crystalline rock.

As in the Alps, they are of a very irregular and varied composition; they are generally of a greyish colour, and contain large quantities of clay and more or less lime. The quartz is generally not present in regular small grains, but either disseminated throughout the rock or entirely absent. The mica is generally present in exceedingly small laminæ. Sometimes considerable quantities of limestone are found between the schists.

These grey schists extend very nearly from the central groups down to the Southern edge of the Himalayan mountains. There they pass very often into clay slates of a more sedimentary character.

We have not been able to discover any fossil remains in the grey schists *themselves*, but in the clay slates into which they graduate to the Southward, we found, in the neighbourhood of Nynee Tal, numerous Foraminifera, evidently identical with those which accompany the eocene numulitic formation; our observations during next year must teach us, whether we shall be justified in drawing a general conclusion from this fact, as to the age of the outer ranges of the Himalaya composed of similar clay slates.

14th. It was observed a long time ago, that in the great mass of grey schists which must be traversed before reaching the central group of the Himalayas, a remarkable uniformity in the dip of

of the gneiss dip from both sides *under* the highest part in the centre, where they stand vertical, so that by drawing a geological section we get a somewhat fan-like form.

apparent stratification prevails. Our observations have perfectly convinced us that this is no real stratification, but merely *cleavage*, produced, as is now generally assumed, by a great tension in the interior of the highly altered rocks.

The general dip of the cleavage planes is in a Northerly direction, deviating in some parts of the mountains to the North-west, and in others to the North-east; and it seems that *in many cases at least the cleavage of the central gneiss masses dips in the same direction* North North-east, or North North-west.

If, after crossing the central groups we continue a geological section into Thibet, we observe that, in the sedimentary fossiliferous strata which are then met with, there occur, independently of each other—(*a*) a true stratification and (*b*) a cleavage, which dips in the same direction, like the cleavage of the crystalline rocks which underlie the sedimentary strata.

15th. This very general Northerly dip of the cleavage continues in the sedimentary formations until we reach the alluvial plain of the Sutlej valley. But it is a fact well worthy of remark, that a perfect change in the dip of the cleavage takes place in the mountain ranges which rise between the Sutlej and the Indus, and to the North-east of the Indus.

We had occasion to examine these mountains along two sections over the Chako La and Phoko La Passes, distant more than 20 miles from each other, in a North-westerly direction. The mountains are composed of various metamorphic schists, intersected with greenstone dykes, running on an average parallel with the mean direction of the chain.

In these mountains, as well as in the similar rocks brought to light by the great denudation of the Sutlej river, we *constantly* found the cleavage dipping under angles of 45° to 70° to the *South* or *South-west*.

This dip is exactly opposite to the dip of the cleavage in the Himalayas.

It therefore seems that, taking a general view, the cleavage in the Himalayas of Kumaon, and in the mountain ranges which face the Himalaya to the Northward, forms one great fan, of enormous dimensions, the cleavage dipping in the Southern part of this fan to the

Northward, and in the Northern part to the Southward. It is only with some hesitation that we venture to bring forward this opinion. Our observations during next summer in a part of the Western Himalayas, and of Ladak, must show whether this structure can be considered a general one or not.

Sedimentary Strata.

16th. In the sedimentary strata, which, as it has long since been ascertained, compose the northern flanks of the Himalayas, we met with—

(1) The silurian and devonian formations, the latter being characterised by the appearance of numerous large and long-winged spirifera; and (2) the trias with several ammonites, closely allied to those which characterise the trias of the Alps, and the Jurassic formations. The latter is divided stratographically into two great groups, the lower one composed of black and bluish slates and marls, containing in many places large numbers of well-preserved ammonites, the upper group consisting of limestones and marly limestones of different colours, which seem not to contain any ammonites, but are very often full of bivalve shells, comprising small and large oysters, pecten, a very characteristic and common species of Astarte, a Trigonia, which we think will not be distinguishable from the wide-spread Trigonia costata, found also, if we recollect rightly, in Cutch, &c.

Amongst the numerous ammonites which we had occasion to collect in the lower group from different localities, we found nothing which would indicate an age as old as the lias.* They all are of forms which characterise, in Germany and England, about the middle part of the jurassic formation. Whether the lias formation exist in these parts or not, is a question which as yet we are not quite prepared to decide.

We have no books at hand to examine as minutely as necessary, some small fossil remains of pentacrinus and terebratula, which we found in such a stratographical position, that they may perhaps belong to this formation.

* The collections made by Captain R. Strachey in 1848, were, we believe, the first which showed clearly that the ammonitic deposits were younger than the lias.

We have been unable to find any traces of a cretaceous or numulitic formation in these parts of the Himalayas, the tertiary strata of the Sutlej basin repose immediately upon the Jurassic formation.

Valley of the Sutlej.

17th.—The alluvial deposits which we meet after traversing the sedimentary strata on the northern flanks of the Himalayas, do not form an elevated plain bordering the Himalayas to the Northward, as the plain of Hindustan does in the Southward; they are merely alluvial and lacustrine deposits, filling up the inequalities of one of the largest longitudinal valleys of the world. On the other side of the Sutlej, and of the Indus, new high mountain ranges rise covered with snow, and very probably bearing glaciers, which evidently belong to the same system of mountains. Looking from a high station like Gunshankoerr peak near the Indus (19,640 E. F.) over the Himalaya mountains to the South, and the long range of mountains to the Northward, the mind is strongly impressed with an idea of the unity of both mountain systems, in reference to orographical and geological structure.

It is evident that the Himalayas form only one incomplete part of the great mountain system of High Asia; the numerous large rivers descending from the Himalayas to the South into India, all run through lateral transverse valleys, which might perhaps be compared with regard to their position in the general mountain system (though of course *not* with regard to magnitude) with the numerous parallel transverse valleys running from the Pennine Alps into the Rhône, or from the Tauern chain in the Tyrol into the Salzach and the Draw.

18th. The tertiary deposits in the basin of the Sutlej are of a fluviatile and lacustrine nature; they have been deposited in a large fresh-water lake, probably formed by a rocky barrier, formerly existing at the place where the Sutlej now penetrates the Himalayas.

We found in them numerous fresh-water shells near Mangnang and Tosing; besides these they contain many remains of vertebrata, we were able ourselves in the neighbourhood of Mangnang to pick out from the rock some of these fossil remains, and ascertained the localities where others which we bought were procured.

The deposits consist in part of gravel and sand, in part of very finely grained clayey and calcareous strata, of a light yellowish colour. They are interstratified with each other; the shells are chiefly found in the marls and clays, which are specially predominant in the central parts of the basin; and at Mangnang, Tosing, &c. the fossil bones are found both in the marls and in some fine grained sands which accompany them.

The strata lay everywhere quite horizontal. The thickness of these deposits is very variable, since the original rocky surface of the valley is very undulating, as is shown in the deep valleys of denudation along all the rivers.

The average thickness may be assumed to be from 1,000 to 1,500 E. F. but the maximum exceeds 3,000 E. F.

19th. The Sutlej and its numerous tributaries in Thibet, form one of the finest examples of the mode in which the erosive power of water acts upon loose deposits and upon solid rocks, under various circumstances. The rivers have excavated valleys of denudation 2,000 and sometimes even 3,000 English feet in depth. These valleys are not excavated in the lacustrine tertiary deposits only, but very generally along the Sutlej, solid rocks are cut through to a depth of 1,000 and 1,500 E. F. This great depth of the valleys of denudation is evidently due to the fact, that the Sutlej afterwards enters the Himalayas where the fall of the river per mile is enormous. The great acceleration experienced there, has been gradually reaching upwards, and has affected the whole river system of the Sutlej basin.

When re-entering the Himalayas, after having examined these great denudation valleys, we proposed to ourselves to investigate the effect produced by the Himalayan rivers, which have such an enormous fall per mile, upon the excavation of their valleys. We soon convinced ourselves that, though the general direction of these valleys was without doubt originally caused by faults, and by the general arrangement of the mountain chains, their forms had afterwards been altered to an immense extent by the action of the rivers, and by the rain falling in enormous quantities during the rainy season. We have ample proofs by the existence of ancient river deposits, and water marks, at great heights above the present rivers, and from the form of the valleys themselves, that most of the large transverse valleys of the Himalayas have been excavated to a depth of more than 3,000 and 4,000 E. feet by the action of water alone.

20th. We noticed also the absence of true erratic blocks both in the Himalayas and in Thibet, which are so numerous round the Alps of Europe.

Glaciers.

21st. Glaciers sometimes of great extent are found everywhere in the Himalayas round the central groups. They even exist in Thibet, where the fall of snow is so much less, and we have every reason to believe, both from what we saw ourselves, and from the information which we received, that glaciers are again met with in the ranges to the North and North-east of the Indus.

The two largest glaciers which we have been able to examine, are the glacier of Milum and the Ibi Gamin glacier, issuing from Ibi Gamin into Thibet and giving origin to the Mangnang river. These two glaciers are certainly larger than any in the Alps, but, as a general rule, we may say, that the glaciers of the Himalayas are not so much larger as we might expect from a consideration of the great extent and elevation of these mountains. One cause of this phenomenon may be, that the high valleys of the Himalaya have, in general, a greater and more precipitous slope than the corresponding valleys in the Alps, so that the ice is carried down too quickly to lower and warmer places; the heavy rains during the warmest part of the year, will also tend to melt away the ice.

22nd.—During the course of our journey, we visited and examined, to some extent, more than 40 glaciers, which, according to the classification in the Alps, must be termed glaciers of the first order. The largest accumulation of great glaciers in the Himalayas of Kumaon, Gurhwal and Bisser, is around the great group of the Ibi Gamin peaks.

The physical structure of the glaciers of the Himalayas, the laws of motion, the distribution of the moraines and of the crevasses, is precisely the same as in the glaciers of the Alps. We could constantly trace also the blue bands of ice, or "ogives" which form such a characteristic physical phenomenon in the Alpine glaciers.

Amongst the results of our observations we may briefly mention two points.

23rd.—We have collected many proofs that, as we formerly maintained, in accordance with Professor T. Forbes' views, the original stratification of the snow which fills the upper part of the glacier basins, is perfectly destroyed during the process of the transformation of the snow and nêves into glacier ice; the blue bands and ogives of the glacier, properly speaking have no connection with the former stratification of the snow.

24th.—At several glaciers, especially at the great Ibi Gamin glacier, we found the curious phenomenon which we formerly described in the Alps, under the name moraines de néve; that is to say, we observed in several instances, that different affluents of one glacier were separated, not by the layers of stones called moraines, but by a small band of néves squeezed in between the two affluents. Lower down in the course of the glacier when the néves disappeared, they remained nevertheless distinctly separated by considerable depression between them; moreover, the individuality of each affluent was proved by a perfectly independent arrangement of the blue bands and ogives. This phenomenon shows well, that the heaps of rocks which generally lie along the line of demarcation between two affluents of a glacier, are quite of a superficial nature, and that the real separation is entirely due to the interior structure of both tributaries.

25th. As a general phenomenon we must finally mention that, on all the glaciers of the Himalayas which we examined, with scarcely one exception, we found most evident proofs that they are at present smaller than they were at some former period. We constantly found heaps of moraines at a distance of from several hundred to some thousand feet, in a few instances even of some English miles, from the present ends of glaciers; the height and thickness of the ice had also been proportionally larger. The Thibetan glaciers afford peculiar facilities for the investigation of these phenomena. Their moraines consist principally of fine gneiss rocks brought down from the higher mountains. The ancient moraines of white gneiss deposited upon dark sedimentary schists, can be very distinctly traced to a distance of from four to five miles from the present ends of the glaciers of Ibi Gamin, of Joharna, and of Photi, and are elevated some hundred feet above the present level of the ice. This greater extension of the glaciers has evidently belonged to the historical period, since the ancient moraines repose constantly upon all the older tertiary and diluvial strata, and if we are not mistaken a diminution in the extent of *some* of these glaciers is still going on at present.

We wish especially to remark, that this greater extension of the Himalayan glaciers, at some former period, is a phenomenon very different from that which gave rise to what has been called in Europe the "glacier theory," by which an attempt was made to explain, on the hypothesis of a former enormous extension of the Alpine glaciers, the existence of the great erratic deposits all around the Alps, where the erratic blocks are in situations very different from the ancient moraines in the Himalayan glaciers.*

We are not as yet prepared to give an opinion about the physical causes (changes of climate, and general subsidence or elevation,) which may have produced this difference in the extension of the glaciers.

(Signed) ADOLPHE SCHLAGINTWEIT.
ROBERT SCHLAGINTWEIT.

Agra, November 24th, 1855.

A short account of the Journey from Milum in Johar, to Gartok in the Upper Indus Valley, and of the ascent to the Ibi Gamin Peak, by ADOLPHE SCHLAGINTWEIT *and* ROBERT SCHLAGINTWEIT.

We left Milum on the 6th of July, with Mani, the Putwarri of Johar, and a good number of Jubboos and people, since we wanted to send all our baggage by the upper road to Niti. After crossing the Uta Dhura Pass, we went up, with a few people only, to the Janti Pass, (18,650 E. F.,) where we staid for three days, which

* That I may not be misunderstood, I must refer here to the remarks on this difficult subject, contained in the first and second Volumes of the Researches in the Alps, published by my brother Hermann and myself.—ADOLPHE SCHLAGINTWEIT.

gave us an excellent opportunity of making several physical experiments at a somewhat considerable height.

From this point we went on to Laptel, where we were much disappointed at finding that the Thibetan authorities had done us the honor to give us a guard of nine Hunias, who wanted peremptorily to prevent us from crossing over into Thibet Proper. We staid at Laptel three days, and there as well as at Janti succeeded in making a tolerably complete collection of fossil remains from the Silurian up to the younger jurassic strata.

In order to deceive our Hunia guard, we went along the Niti road as far as Selchell, and from thence tried to make our escape in the night of the 16th of July; we left all our camp behind, and took only four Bhutias, and the most necessary instruments and provisions with us. We had mounted our four Bhutias, and four horses were sufficient to carry all our baggage. We went on during the night and during all next day, and in the evening we had arrived on the alluvial plain which fills up the broad valley of the Sutlej. We thought ourselves now pretty safe from discovery, and were just about to put up for the night in a little valley, when we discovered our Hunias on horseback following our track. Mani especially told us not to shew the least fear of them; they came on crying and hurraing, and the two first of them who got up to us tried to get hold of the bridles of our horses; but we gave them some severe blows with our hunting whips right over the face, which took them much by surprise. They immediately dismounted, making their salams, and saying that they were our friends, (we had given them some rupees at Laptel,) but that they had received strict orders to accompany us as a guard. One of them was a Kuchop, or Thibetan Chuprassi; they said that these strict orders had been given on account of the present wars with the Nepalese, since the authorities were afraid that we might be plundered or killed, and that they might afterwards be held responsible for it by the Indian Government. We ordered one of them to go to Daba (which was not very distant,) and to tell the Jungpun, or head Thibetan authority there, to come out and make the necessary arrangements with us. As we had expected, the Jungpun did not make his appearance himself, but his head clerk, or Dink, a decent looking young Lama from Lhassa came out the next morning, saying that his master had gone to Chaprang (which was of course a mere lie). We had convinced ourselves that during the present war it was impossible for us to go to Mansarower, since even the Bhutias had been robbed and molested by the disorderly Thibetan soldiers, but we determined to try whether it might not perhaps be possible to proceed to the Upper Indus valley, near Gartok, which had only hitherto been visited by Moorcroft in 1812. After endless negociations with our Dink, supported by rupees, brandy, &c., we succeeded in obtaining permission to proceed as far as the Sutlej. We signed a written agreement, stating that we were allowed to remain three days on the Sutlej, and that we were to pay a fine of Rs. 600 if we crossed that river. Accordingly we went on to the Sutlej near its junction with the Gyungul river. After staying there two days, engaged with astronomical and geological observations, we were met by the Bara Mani (Mani's cousin) who had come out to our assistance. He is the welthiest of the Milum people, and has really got much influence in Thibet. He had come a day or two before to Daba, where the Jungpun is his friend and owes him some thousand rupees, and he and the seven Niti Pathans, who happened to be in Daba, negociated with the Jungpun, and must have made a considerable disturbance in the place, telling the Jungpun that we were not people to be ill-treated and driven out of the country with impunity. After two days, the Bara Mani and two of the Jungpun's clerks came to our camp; our brave Bhutias had really succeeded in obtaining permission for us to proceed as far as the Chako La Pass, which lies in the ridge which separates the Sutlej from the Indus. The Hunias had now become quite friendly, and the two Lhassa officials exchanged with us some little presents. We bought from them a number of Chinese articles at an extravagant price, and before long they had all got the conviction that there was no harm in our staying for some days in their country.

Permission had been granted us to remain five or six days on Chako La and the two Manis had pledged themselves in writing to pay a considerable sum if we should go any farther or remain any longer. We were only accompanied by two people of our guard, the others had found it more comfortable to remain at the foot of the cold mountains near the Sutlej. We lost no time in making the best use of the few days granted to us. On the 26th we arrived on the Chako La, and placed our camp as close as possible under the pass itself.

On the 27th in the early morning, we went away. Numerous Bhutias (who all did what they could to assist us) and Hunias were constantly crossing the pass with their sheep. To avoid suspicion, we left our little tent and the greater part of our baggage, and one of our Bhutia servants behind; one Hunia, who knew exactly where we wanted to go, accompanied us; two horses carried our theodolite, hypsometric apparatus, and some provisions. We told the people that we only wanted to go to a mountain near the pass, to look at the "compass." After crossing the pass, we left the usual track, and went on through a lateral valley. To our great astonishment, we found that the lower part of the valley was filled with more than a hundred of armed Hunias, and our people got much frightened, saying that these men were sent out by the Garpon or resident of Gartok, to catch us, &c. We lay down in a small hole and despatched one of our men to get information. He was soon, however, discovered and surrounded by the Hunias.

We saw with our large telescope that much crying and quarrelling was going on below; they searched his horse and got hold of his gun. After some time, however, they let him go. He had found among these people, who came from Chumurti and were going to the seat of war, one old friend, who had settled every thing. He had told them that we were Gurhwal people and had been afraid of being plundered if we went down into the valley. In the evening we went down a little lower along a small valley, just on the limit of the highest shrubs. The night was unhappily a very bad one. Without a tent, and with only a few blankets, we lay down as close together as possible; in the morning, we were covered with snow more than three inches deep. The sun, however, melted away the snow from the ground, and we were glad to find that the greater part of the troublesome Hunias had gone on early in the morning. We rode as far as we could across the valley where their camp had been, and upon a mountain on the other side of it. The weather had become beautifully clear, and in the afternoon we had the pleasure of finding ourselves in the Indus valley, some miles above Gartok.

From a little hill on the left side of the valley we had an excellent view over the large valley, and over the mountain ranges which border it to the North-east, and we were able to take numerous angles with our theodolites, and to make some drawings. On the 28th we went on to the Indus river itself, and after taking altitudes of the sun, &c., were obliged by the most absolute want of provisions to return without delay along the usual route to our camp on the Southern side of Chako La, which we only reached late at night. The next day, the 29th, we went out over Chako La again with fresh horses, to one of the peaks of this mountain range, Gunschankoerr, which from its isolated position and somewhat considerable height (19,640 E. F.) promised to be a good station for studying the orography of the surrounding country. The view which we had from the top of the mountain was really magnificent. To the North we had high snowy mountain ranges from East of Kailas along the Indus valley far beyond the confluence of the two great branches of the Indus; right at our feet we saw the great plain of the two Sacred Thibetan Lakes (the water itself was only visible in a few small patches) and the pass which separates the Sutlej from the Brahmaputra. To the South the Himalaya was visible from distant snowy peaks in Nepal far East of the Brahmaputra pass, over Gurla Gumin beyond the high peaks of Bessez, Koenower and Spiti. On the 30th we returned to the Sutlej, and from thence we went by Gyungal and Daba to Mangnang. By degrees we had now got upon a very friendly footing with the Thibetans, and they even allowed us to go into the villages of Gyungal and Mangnang. In the latter place they have a fine temple and some high poplar trees. They showed us the interior of the temple, gave us some books, &c., and contantly expressed their surprise that we were not half so bad a set of people as their Lhassa rulers wanted to make them believe all Europeans to be. We had also taught our Kuchop, or Thibetan chuprassie, what the real duties of a good chuprassie were; and he went every day to considerable distances to procure fresh milk, sheep, &c. from the shepherds. From Mangnang we proceeded Southwards to the foot of the great Ibi Gamin glacier (Gamin or

Ibi Gamin is the real Thibetan name for Kamet); we were met there by some coolies from Mana, with provisions, some additional instruments, &c. Ibi Gamin, which, seen from Gunschankoerr over-towered all the Himalaya peaks, seemed to us to be one of the most favorable mountains to ascend with the view of attaining some considerable height. Furnished with axes, ropes and every thing we wanted for the ice, we left our camp on the foot of the glacier on the 16th of August. We were rather surprized to find that the glacier was one of very considerable ascent; it is an exceedingly regular and very fine glacier, somewhat similar to the Aar glacier in Switzerland, but considerably larger. Ibi Gamin seemed to become more distant, the further we proceeded along the glacier, and at last we discovered that the summit was situated in the most remote corner, at its very source. For three days we went up in short stages along the glacier, sleeping on the heaps of rocks, "Moraines," which border it. On the third day, we encamped at the very foot of the Ibi Gamin, at an elevation of 19,220 E. F., where the glacier valley terminates. We had altogether fourteen people with us; instead of wood we were generally obliged to burn a sort of grass called peaug (a species of Cherleria, if I am not mistaken), which we found on the mountains near the lower parts of the glacier. The night of the 18th had been very cold and stormy, but the following morning was pretty clear; we therefore went out at 8 o'clock to see how far we could get upon Ibi Gamin. Only eight of our people were willing to accompany us; the other hands got quite apathetic, saying that they and we were all about to perish. We soon began to ascend over steep snow, often crevassed, which covers the flanks of Ibi Gamin; halting frequently and making a very circuitous route in order to avoid *crevasses*, or places which were too steep to climb, we rose gradually higher. At last at 2 o'clock it became absolutely impossible to go on any higher: two of our people had got sick and had remained behind, and all the rest of us felt exceedingly tired and exhausted, more so indeed than we had ever been before in our lives. The view which we enjoyed was not very extensive; clouds had been constantly passing around us, but in the clear intervals we had a very instructive view over the glacier masses and ridges which surround Ibi Gamin. The highest point which we reached had an elevation of more than 22,200 E. F. (22,260 E. F. calculated from Agra). At 2 o'clock a strong North wind began to rise, and this especially obliged us to descend as quickly as we could; the wind became very strong indeed lower down, and we were glad enough when we had all reached our camp safely in the evening. Ibi Gamin re-appeared for some moments between the clouds, beautifully coloured by the setting sun, and it may be imagined that we all looked back with great pleasure upon our route which was distinctly traceable upon the highest point which we had reached. We had got much accustomed to the influence of height, especially during our Thibetan journey, but here not one escaped unhurt; we all felt head-ache and more or less severe pains in the eyes, the latter being especially caused by the furious wind which constantly blew the fine snow dust into our eyes. The night was a very bad one, we had scarcely any fuel left for cooking, the wind threatened every moment to tear to pieces our light tent, the cold was intense, and our people, with the exception of one, had entirely lost courage and the faculty of thinking. In the morning at 9 o'clock, as soon as the cold was a little less intense, we commenced our descent to our second camp, which was in a somewhat more sheltered position. This day we very nearly lost one of our men. This poor fellow, a man called Dolpa, from Milum, an excellent servant, who had been with us during all the Thibetan journey, was taken ill the day before, when going up Ibi Gamin, and had a dangerous effusion of blood. We of course ordered another man to accompany him in going down to the second camp; but his companion made his appearance soon after us at our lower station, saying that he had lost sight of the sick man in the heavy snow-storm which we encountered on the glacier. We immediately sent back two of our people to look for him and when they returned without him three others started, but they could discover no traces of the missing man. The next day we left behind two other men, with strict orders to look after Dolpa, but all in vain. After our arrival in Mana, we had already made all the arrangements with the Putwarri for the family of the supposed dead man, when to our great delight the poor fellow came in three days after us. He had been lying between some large stones on the Moraine where nobody could see him, and the second day he slowly went down to our first camp at the foot of the glacier. Unhappily our men with the horses and yoobus had already left, and the poor man remained three days without food in the wilderness, when he met some Mana people, who brought him on. He was bad enough, and had his feet injured by frost, but we think that he will entirely recover before long. In the afternoon of the 20th the weather again became fine and clear. We completed our survey of the Gamin Glaciers, and made our preparations for the next day's march. At the camp we had found some wood and fresh provisions which had been sent up by Mani, whom we had left at the lowest station, and all our people recovered again satisfactorily. The great Gamin Glacier, and all the part of the country where we had now been, lies within the boundaries of Thibet. To reach Badrinath we had still to cross a high Glacier Pass. We had heard of the existence of this Pass (quite a different one from the regular Mana Pass) only a few days before from a Mana coolie who was with us; he said that formerly it had once been passed with sheep, but that now it was quite deserted. Neither he nor any other man of Mana had ever made the Pass, but he knew about the direction in which it was likely to lie, and he undertook to find the road and to lead the party. On the 21st we went up along the Western branch of the Ibi Gamin Glaciers and slept on the highest Moraine. On the 22nd, with beautiful clear weather, we proceeded further and after some detours and mistakes, we happily reached the pass as early as 2 o'clock. It was much higher and much more difficult than we or our people had expected. It is no doubt one of the highest passes in the Himalayas, being 20,430 E. F. above the level of the sea. We were extremely glad to have found a passage, since otherwise we should have been obliged to make a long and tedious detour down the whole of the glacier and round the Mana Ghat. From the top of the pass we discovered a large glacier trending to the South-west, and saw before us a considerable part of the range separating the Mana from the Neloug valley. The Glacier was the Sursutti Glacier; we went down along it and at night encamped again on the "Moraine," near a place where we found the first peaug. We broke to pieces all our sticks, tent-poles, &c., and they gave sufficient fuel to prepare some dinner, of which we and our companions were much in want. At last on the 23rd we arrived at Sursutti at the foot of the Glacier, in the valley leading down to Mana and Badrinath. We can readily understand why the people of Mana have given up this dangerous and fatiguing pass, which is certainly ten times worse than the Pindari Pass, on account especially of its great distance from wood and from the nearest villages where any supplies can be procured. We slept a little below Dhanran, where we were fortunate enough to meet some people going to Thibet, who provided us with some rice; and in the evening of the 24th we arrived at Badrinath, where the people had been looking out with some anxiety for our arrival.

Notice on the دوا القلوب *of Mohásaby being the earliest work on Súfism as yet discovered, and on an Arabic Translation of a work ascribed to Enoch.—By* A. SPRENGER, M. D.

Much has been written of late years on Súfism. The greatest advantage of these essays, consists in the ignorance of the authors of what Súfism means. They took a quotation from one book and a quotation from another book without much regard whether they treated on the same subject—and by the illicit process of *humano capiti cervicem jungere equinam* they produced the most phantastic systems, which were sure to be welcomed by an age which loves the *piquant.* Illusion is the greatest pleasure in life, and hypotheses are the charm of science, it is therefore, with some remorse, that I introduce the work of Mo*h*ásaby to the notice of the reader, as it may tend to destroy illusions which some worthy orientalists have conjured up. I am consoled, however, by the consciousness that my notice is extremely imperfect.

It is considered as a settled question that Súfism was from its commencement a system of metaphysics or pantheism; or at least that pantheism was its root and life, and asceticism a later addition. We know that during the Middle Ages, members of religious orders became pantheists but when will the day come that the followers of Spinoza or Schelling will turn ascetics? As to whence this system formantibus. Palpi maxill. art. 4 minuto acuminato. Thorax *amplus semiorbicularis*, margine posteriore medio producto, basi 2-foveolatus. Tarsis art 1-4 subæqualibus.

The colour of this insect is as usual shaded off from brown to light yellow; however, in other respects it differs materially from all the preceding species. The body is regularly oval, thorax and elytra convex, pubescent. The head is subquadratic—ovate; the eyes rather small, but prominent; the neck is altogether wanting. The antennæ are at the base as distant from each other as they can be, being inserted below the eyes; the club is 3-jointed; the joints increase gradually in size from the 3rd to the 11th. The maxill. palpi have the 2nd joint slender, the 3rd rather pear-shaped, the 4th minute and acuminated. The thorax is very ample, semiorbicular, of the shape and nearly the size of the apical half of the elytra; the basal angles are acuminated and slighty envelop the shoulders; the posterior margin is prolonged in the middle, towards the scutellum; the foveæ or basal impressions are 2 and rather distant from each other. Scutellum obsolete. Elytra with 2 depressions at the base. Tibiæ straight; tarsi with joints 1-4 subequal or very nearly so. Mesosternal carina middling.

Report on the Proceedings of the Magnetic Survey, from January to May 1856, *by* HERMANN SCHLAGINTWEIT.

ROUTES.—After having completed the observations at Gowhatty, detailed in my last Report* I left Gowhatty, December 21st, and proceeded up the Brahmaputra to Mungeldie, and from thence to Oodulgoorie on the Frontier of Assam and Bhootan.

I found occasion to proceed from this place into the country of the Kampo-Bhootans, who occupy the Himalayas East of Bhootan Proper; while my Assistant, Mr. Adams, and the Draftsman, Abdool, who accompanied me as far as Oodulgoorie, went to the coal mines and salt wells in the Baree Dihing.

* See Journal No. 1, 1856, p. 30.

I made arrangements, immediately after my arrival at Oodulgoorie, with a former Rajah of Towang-Chang-To, who was found willing to be my guide as far as Nurigoon, which is situated at about one-third of the breadth of the Himalayas.

I staid four days at Nurigoon, and besides taking magnetic observations, (the instruments had been, till used, carefully concealed in cotton bags,) I succeeded in making an excursion to the Zinghyla (Deer Mountains) in order to survey the different valleys and make some drawings.

Here too I got some very valuable information (not from the inhabitants, but from traders coming down from Thibet) about the routes to Lowany, only 4 marches distant, and to Lhassa.

A very intelligent Bhootea from Tussisoodun even constructed a map, with a vertical Section in the Chinese style, of the route from Nurigoon* to Lhassa, which agreed very well with the verbal information I received from the Thibetans.

Nurigoon is situated on a rock on the left side of the Riju at a height of from 3,200 to 3,500 feet, and offers many interesting features for comparison with the Western Himalayas.

The valleys here rise much more *gradually* than in the Western parts of the Himalayas; at the same time the height of the mountains is less and the inclinations less steep. The vegetation has the luxuriant character peculiar to the Eastern Himalayas, though the quantity of rain is much less than in the lower ranges of the Naga, Khosia and Garrow Hills, on the left side of the valley of the Brahmaputra.

Yâks come down from Thibet as far as Nurigoon in the cold season and chiefly towards the end of it, when the trade with the plains is greatest; and wild elephants are very frequent in the valley of the Dhunsiri and the Riju, and are occasionally met with even a little above Nurigoon. Such coincidences of lower and upper limits of animals, so different in reference to their zones of altitude, may perhaps be not without interest in explaining the variety of fossil remains in places which were formerly under similar local and climatological conditions.

* This Map is included in the drawings, portfolio the 6th, sent from Calcutta to the Hon'ble the Court of Directors.

I left Nurigoon January 13th and went to Tezpore, and from thence to Debrooghur in Upper Assam, where, besides, my own observations, I obtained much valuable information, particularly from Colonel Hannay, about geological subjects.

From Debrooghur I descended the Brahmaputra and went by Goalpara, Serajgunge, Koolna, and through the Sunderbunds to Calcutta.

After a stay of twenty-nine days I proceeded by Cawnpore, Agra and Umballa to Simla, visiting Lucknow in Oude and Meerut for magnetic observations.

I arrived at Simla on the 24th. From hence Ladak, and the ranges of this part of the Himalaya and the Kuenluen, will be examined.

Two of the four Sikim men I had with me in Sikkim and Assam, the Lepcha Chezy and the Bhootea Dublong, are to make some observations during this summer in Sikkim, furnished with some thermometers, a boiling thermometer, and a prismatic compass.

Mr. Montairo, attached to my Establishment for collections, left Darjiling August 23rd, and went to Calcutta, where he received, and packed for transmission to Europe, the collections sent down to him from the Khosia Hills and Assam. He arrived at Simla May 20th. He is going *vià* Kangra to Kashmere.

MAGNETIC OBSERVATIONS.

Magnetic observations have been made at the following Stations:—

A—*Assam and Delta of the Ganges.*

1. *Oodulgoorie*, on the Bhootan Frontier—December 30th and 31st, 1855, January 1st, 2nd, 3rd and 4th, 1856. Declination, horizontal intensity, vertical intensity, and a set of observations for ascertaining the daily variations, longitude and latitude.

2. *Nurigoon*, in Bhootan—January 9th, 10th and 12th. Declination, horizontal and vertical intensity, longitude and latitude.

3. *Tezpore*, on the right shore of the Brahmaputra—January 24th, 25th and 28th. Declination, horizontal and vertical force, longitude and latitude.

4. *Debrooghur*, Upper Assam—February 5th and 6th. Declination, horizontal and vertical intensity, longitude and latitude.

Gowhatty—*see* preceding Report.

5. *Serajgunge,* on the right shore of the Kenur River— February 17th. Vertical intensity.

6. *Dacca*—February 21st. Vertical intensity.

7. *Koolna,* on the right shore of the Bhogrup—February 24th. Declination, vertical force, longitude and latitude.

8. *Calcutta,* Botanical Garden, March 23rd and 24th. Declination, horizontal and vertical intensity, longitude and latitude.

B—*Plains of the Ganges in Hindoostan.*

9. *Benares*—April 3rd and 4th. Declination, horizontal and vertical intensity, longitude and latitude.

10. *Lucknow,* Oude—April 8th and 9th. Declination, horizontal and vertical intensity, longitude and latitude.

11. *Agra*—April 15th. Declination.

12. *Meerut*—April 18th. Declination.

The magnetic elements were therefore determined from between latitude 22° to 27° 5′ N. in the valley of the Brahmaputra, and to 29° in the plains of the Ganges including a difference in longitude of 16° 5′ from 95° to 78° 5′ East of Greenwich.

One of the general results was, that the magnetic force, particularly the dip, has been found much greater than is indicated by the general formulæ.

The Dip.

A.—In the valley of the Brahmaputra and delta of the Ganges, *the dip* was found to be—

At Debrooghur, ...	38°	29′	17
„ Tezpore, ...	37	14	58
„ Oodulgoorie, ...	36	27	52
„ Nurigoon (Bhootan,)	37	11	69
„ Gowhatty, ...	35	18	73
„ Serajgunge,..	32	3	15
„ Dacca, ...	31	0	80
„ Koolna, ...	29	18	49
„ Calcutta, ...	28	6	4

B.—In the plains of Hindoostan it was—

At Benares, ...	32	40	9
„ Lucknow, ...	35	18	20

A similar result has been found by my brothers for the parts of corresponding latitude in the North-West Provinces and in Central India.

The Southern part of India seems to agree better with the results of calculation.

The Declination.

The declination was not found to alter so irregularly in any of the places examined, as we formerly found to be the case at Cherrapunji, though the granite rocks in the valley of the Brahmaputra on both sides of the river are identical with the rocks of the Khosia and the Garrow Hills along the left edge of the Brahmaputra valley, and the geological situation of the Himalayas along the right side of the valley is very different. Some of these rocks in the valley contain, as well as in the Northern parts of the Khosia Hills, a very great amount of magnetic iron (in the rocks near Doobree, Colonel Hannay recently has found it particularly predominant); but the action on the needle is confined to the place itself, and becomes at a very small distance untraceable.

The declination in the territory examined was *East*, being greatest at Koolna and decreasing East and West of it. In Assam, as well as at Meerut, a small increase is caused by the difference in latitude. In Nurigoon, as in the Himalayas in general, the declination is decidedly greater than the difference of latitude would lead us to expect.

A.—In the valley of the Brahmaputra and Delta of the Ganges, the *declination* was found to be—

At Debrooghur, ...	N.	2°	8′	E.
„ Tezpore, ...	N.	1	59	E.
„ Oodulgoorie, ...	N.	2	5	E.
„ Nurigoon (Bhootan,)	N.	4	5	E.
„ Gowhatty, ...	N.	1	41	E.
„ Koolna, ...	N.	2	55	E.
„ Calcutta, ...	N.	2	24	E.

B.—In the plains of Hindoostan—

At Benares, ...	N.	1	27	E.
„ Lucknow, ...	N.	1	12	E.
„ Agra, ...	N.	1	14	E.
„ Meerut, ...	N.	1	28	E.

METEOROLOGY.

In Assam, observations were made on the variations of the temperature of the Brahmaputra, from Debrooghur to its ramifications in the Delta, a subject of particular interest. Also, besides the regular observations on the temperature, moisture, and pressure of the air, I made several experiments on the thermic influence of surfaces covered with grass and tree jungle; and Dr. Simmons, at Gowhatty, kindly assisted me during my absence, by making observations on the ozone contained in the air, with papers identical with those used by myself.

These observations are being continued for the next year.

The following Table contains* the temperature found in the Brahmaputra, in its ramifications, and in the Delta, from Debrooghur to Calcutta. The daily variations, even in Upper Assam, scarcely exceeded 0.5 degrees C. = 0.9 degrees F., but occasionally differences of 2 to 3 degrees F. are found even in the very current, caused in some cases by differences of depth, in others by lateral rivers discharging themselves into the Brahmaputra.

I choose for the Table the temperature of the rivers at 11 A. M., this hour representing very nearly the mean of the twenty-four hours for the water; for the temperature of the air for the same reason the temperature at 9 A. M. is selected. Errors of the zero points of the Thermometers Nos. 29, 70 and 88 are corrected.†

* A second series during the hot season is now being made by my Assistant, Mr. Adams, on his way down from Sudiya.

† For the Hooghly, at Calcutta, I was furnished with observations on the monthly variations of the temperature at high and low water by the kind assistance of Mr. Schiller. The observations are now being continued by Dr. Thomson.

Temperature of Rivers.

Names of Rivers.	Names of the nearest Places.	February 1856.	Temperature of the water at 11 A. M.	Temperature of the air at 9 A. M.
			° Centigrade.	° Centigrade.
Brahmaputra,...	At Debrooghur,... ...	6	15.6	12.4
" ...	Above Dikhoo Mookh,...	8	15.7	12.6
" ...	Above Dhunsiri Mookh,	9	16.2	13.7
" ...	Tezpore,...	10	17.1	16.2
" ...	At the mouth of the Kulluny, ...	11	17.2	15.8
" ...	Gowhatty, ...	13	17.5	14.6
" ...	Above Doobree,... ...	14	17.8	17.0
" ...	Below Doobree,... ...	15	18.4	19.3
" ...	Bugwa, ...	16	19.4	18.6
" ...	Hajeepore, ...	17	19.3	18.7
Zuboona, ...	Serajgunge, ...	18	19.6	20.7
" ...	Amerbad, ...	19	19.7	22.1
Kertinana, ...	Senpore,...	20	21.2	21.7
Bargunga, ...	Kalaghaut, ...	21	22.8	22.8
Damudar, ...	Burrissole, ...	22	21.6	21.8
Charcollee, ...	Bidaboorea, ...	23	21.6	21.4
Passur, ...	Koolna, ...	24	22.0	20.5
Seprah, ...	Near Grant No. 214 Sunderbunds, ...	25	23.5	23.4
Terra Banka, ...	Near Grant No. 155 Sunderbunds, ...	26	23.8	25.5
Moree Gunga,...	East of Saugor Island,...	27	24.6	26.1

The variation of the temperature of the air is 26° 1—12° 4=13° 7, C., of the water 24° 6—15° 6=9° C.

In the Dhunsiri and in the Riju, the difference between the temperature of the Dhunsiri near Orang in the valley of Assam and of the Riju, a lateral affluent of the Dhunsiri at Nurigoon, was

Dhunsiri, ...	18° 1
Riju, ...	9 0
Diff	9 1 C.

During my journey from Calcutta to Umballa, I also several times, tried some experiments to measure the heating power of the sun's rays under various conditions.

I used for a complete observation, the following thermometers :—

1. } Dry and wet bulb for temperature and moisture of the air.
2. }

3. A thermometer exposed to the sun with white bulb. It had no brass scale, and a very thin capillary tube for the mercury, surrounded by a larger glass tube, the ordinary form of thermometers on the Continent. The advantage of this is that the instrument indicates nearly without error the temperature of the mercury in the bulb unaffected by the disturbing influence of appendices. But even in this shape, a thermometer offers no absolute measure for insolation, the whiteness of the glass forming the bulb, its colour and transparency modifying very appreciably the apparent action of the sun on different instruments.*

4. A thermometer of a similar construction, with blackened bulb.

5. A Kew standard thermometer, with thick glass tube, the divisions being in the glass stem. It had its bulb blackened, and also half of the mantle of the cylinder behind the divisions. This, as well as the following, was placed on a large surface of black wood, which getting heated all round, very nearly as much as the thermometer itself, prevents an irregular loss of heat towards objects of different temperature in its vicinity; the presence of grass or gravel, for instance, would otherwise affect the reading of the thermometer. It may be considered as a good proof of the comparability of the thermometers in such an arrangement, that the Kew standard and the following thermometer, No. 6, stood very nearly alike.

6. A boiling thermometer, every degree divided into 50ths, the mercury begins to reach the divided scale only at 78 degrees C., being intercepted by a second enlargement of the tube. Bulb blackened. The mercury contained in the capillary tube being here only a very small part of the mercury under the black stratum, and being protected besides by a second outer glass cylinder against loss of heat, I found this instrument the best for these experiments as long as the insolation was hot enough to raise the mercury to the divided part. Besides, the $\frac{1}{100}$th of the degree being read with perfect accuracy, it showed very rapidly even the minutest changes in the atmospheric conditions.

7. The surface of the ground. The thermometer was placed in the reddish sand forming the general deposit in the plains of Hin-

* For relative determinations for distance, and for the annual and daily variations, careful observations with any thermometer would be very useful.

doostan. It was during the first experiments covered with a stratum of the sandy soil about one centimetre thick, but in the experiments at Umballa a little hole was filled with mercury and this covered with the stratum of soil. By this arrangement the thermometer was kept through the medium of the mercury, in a much more intimate contact with the particles of the soil, the temperature of which it was to indicate.

8 and 9. Metals exposed to a tropical sun feel remarkably hot when touched, but this is due in a great measure to their conducting power. Their real temperature seemed an interesting object for direct determination. I therefore exposed two metal vessels, the one an iron bottle, well screwed and filled with mercury to two-thirds of its volume; the other a flat square copper basin (used generally as an artificial horison,) blackened, with about two cubic centimetres of mercury distributed over it in isolated drops. Both were put upon a soft and thick layer of cotton. In making the observation with the copper basin, the cotton was slightly pressed down at one side, so as to incline the basin without the necessity of touching it, causing the mercury to collect in one corner. The thermometer was then dipped into the mercury, which it might be expected had assumed the temperature of the metallic surface with which it was in contact.

The following Table contains the reading of the different thermometers at Umballa; the correction for index errors are applied to the reading. The instruments with black bulbs and on black wool were read with a telescope from 4 to 5 feet distance, since any near approach to read them with a magnifier altered very suddenly the indications of the thermometers.

Observations on insolation at Umballa, April 22nd, 1856, Centigrade.

Hours, local time, ...	6 A. M.	7-15	8	9	10	11	11-54	1-4 P. M.	2	3	4	5-30
Height of the Sun, Latitude 30° 20′ 7″ N., ...	° ′ 6.12	° ′ 18.7	° ′ 31.9	° ′ 44.75	° ′ 56.9	° ′ 67.25	° ′ 71.9	° ′ 60.5	° ′ 56.9	° ′ 44.75	° ′ 31.9	° ′ 12.6
Air, ... Dry,...	21.2	22.8	24.7	33.1	34.3	36.4	38.2	39.3	39.7	39.4	39.3	39.3
Air, Wet, ...	9.5	10.0	12.1	16.3	16.4	17.2	18.3	18.0	18.0	17.9	17.9	18.0
Sun, ... White, ...	...	...	...	36.3	37.7	41.4	42.2	43.4	43.4	42.7	41.4	40.7
Sun, Black, ...	...	...	...	38.4	40.8	44.1	45.8	45.2	45.1	45.1	42.9	42.3
Sun, ... Keen, ...	...	...	...	57.5	77.2	73.9	87.5	67.9	67.4	58.2	52.0	49.0
Sun, Boil, ...	...	...	...	...	80.65	...	89.47	...	...	...	...	...
Surface of Ground, ...	In shade 19.3	In sun, 32.3 Shade, 21.0	...	...	44.3	47.9	50.2	51.7	51.9	49.9	48.2	44.2
Metal, ... Black Surface, ...	...	...	...	...	...	...	...	55.2	55.2	53.7	50.3	
Metal, Metallic Surface, ...	...	...	...	...	...	...	...	54.4	54.2	52.0	50.5	

Remarks.—Some small clouds at 11 A. M.; hazy, but no clouds from 12-10, with W. by N. wind; hot wind.

The haze, during the experiments at Umballa, though generally accompanying the hot winds, modified the heat, particularly for the boiling thermometer; also the small clouds, though very thin, and not covering the sun at the moment of the reading, had caused a sensible depression in the black thermometers *on the wool;* the other black bulb, freely suspended, being much less sensible for the rays of the sun, since the objects against which it radiated changed their temperature but very little (*see* " Surface of Ground,") went on steadily rising.

The great heat of the *air* lasting till sun-set is very characteristic of days with hot winds in general; also the surface of the ground keeps remarkably warm during the first hours after sunset though it loses 25 degrees C. during the night.

Notwithstanding this great variation, no particle of dew is deposited in these regions during nearly three months, the wet bulb thermometer sinking even 10 degrees lower during the night than the dry one.

The power of the sun's rays was also determined at Benares and Cawnpore.

At Benares the boiling point thermometer, in an arrangement like the one just described, was exposed on the 3rd of April.

It stood at 12 H.	30 M., ...	78°.15	Centigrade.*
1 "	5 "	82.60	"
1 "	10 "	84.23	"
1 "	15 "	84.08	"

The maximum seems to fall decidedly after 12, (the sun's power decreasing less rapidly than the loss of radiation is diminished by the general increase of the temperature of the air continuing till 2 or 3 P. M.) The maximum on normal days, without clouds, and with very light wind, seems to be reached pretty regularly at 1*h.* 10*m.* to 1*h.* 20*m.* P. M.

At 1*h.* 29*m.* the wind at Benares became more violent, about 6.5 metres per second, and *felt* very hot. To my surprise the thermometer immediately went down, the thermometer with the white bulb in the sun also fell, though very little. Evidently the instruments had gradually surrounded themselves with a stratum of

* The readings are corrected for index errors.

heated air, corresponding with the temperature of the mercury, which, during the periods of stronger wind, was removed, and replaced by one less hot.

The readings were

At 1-42 P. M. .... 82.60 Centigrade.

(Wind increasing very much at 1.44 P. M.)

Thermometer at 1.46 P. M. .... 78.74 „

It rose again, in a slight lull, from 1.53 to 2.10 P. M.

It stood at 2.10 P. M. 80.45;

then the wind setting in again, it gradually sank, and soon (2.35 P. M.) disappeared below the divided scale.

At Allyghur, April 17th, the day was particularly clear; the West wind hot, but not very strong. Here I found the highest temperature I had yet observed, *viz.* 90° 30 C. or 194 54 F,* the time of this maximum, 1.20 P. M., coinciding very nearly with that observed at Benares.

I was enabled to compare my instrument with one used by Mr. Gubbins,† the bulb of which was protected against lateral radiation, by being enclosed in a double cylinder of glass. The two instruments agreed, at least for the maximum, better than might have been expected. The time of the maximum was naturally, not so well defined in the one enclosed in the glass tube, as in the other lying on wool: the former was too cold before the period of its maximum, too warm afterwards. The readings were on April 3rd—

	Schlagintweit. Hypsometer No. 5.	*Gubbins.* In glass cylinders.	Black bulb exposed free.
12·0	88.58 C. 191.44 F.	190.5	126.0
1·15	90.13 C. 194.23 F.	Disturbed by approaching too near.	127.1
1·20	90.30 C. 194.54 F.	189.5	128.5
1·45	86.10 C. 186.98 F.	188.0	119.0
2·35	80.60 C. 177.08 F.	185.0	122.0

* Corrected as the following for index error.

† We are deeply indebted to Mr. and Mrs. Gubbins for the communication of

When the hot winds are very violent, they diminish the power of insolation very much owing to the quantity of dust they raise, which very often, like thick aqueous clouds, completely hides the position of the sun, and sometimes even produces a darkness like the thickest fog.

I noticed a peculiar coloration of the sun during dust-storms, which is, I think, a regular phenomenon accompanying them, when the air has lost a certain amount of transparency.

In fogs the disk of the sun is red, or at least of a decided reddish tint, when sufficiently darkened to be looked at without a dark glass. In dust-storms the sky has also, as in fogs, a decidedly reddish colour, which in this case is that of the dust itself, but the sun's disk is blue, a phenomenon evidently connected with the suspension of solid particles in the air.* I observed this colour best on the 6th of April at Futtehpore. The hot wind lasted from 12.45 to 6.10 P. M., and stopped very suddenly after sunset. The sun was very much obscured as early as 1 P. M., and had then assumed this blue appearance so decidedly, that it looked like the sun's disk seen through a dark-blue glass, the shadow of a thin cylinder falling on white paper was nevertheless well defined and reddish, showing that the illuminated paper had received rays of the (complementary) bluish colour.

The blue colour of the sun, though the light was gradually much diminished, lasted until 5.10 P. M., when the sun had a height only of about 15 degrees: then the disk soon disappeared entirely behind the clouds of dust.

The temperature of the air† was corrected for index errors on the 3rd of April—

a series of most accurate meteorological observations, which not only embraced the ordinary objects of observation, but in which, at the same time, a great variety of experiments were combined with equal skill and ingenuity.

* A similar dust-cloud passing perhaps at a small height above the ground may explain the blue appearance of the sun mentioned in the Second Edition of Sir John Herschel's *Astronomy*.

† A room with tatties was easily kept at 25° to 27° C. in the centre of the apartment, the wind being very strong.

	Dry.	*Wet.*	
At 12, ...	38.2	19.9	Direction of the hot winds West, very strong, from 12.45 to 6.10.
1, ...	38.1	19.0	
2, ...	37.3	19.3	
3, ...	37.3	19.3	
4, ...	37.3	19.2	
5, ...	36.7	19.1	
6, ...	36.4	18.9	

The temperature of the air diminished, as occasionally noticed in the observations above-mentioned, with the increase of the wind and discoloration of the air.

A coincidence worthy of notice is the sudden cessation of the wind after sunset, which took place at every one of my observations. Generally speaking, it is characteristic of the hot winds that in the beginning of the hot season the wind always ceases very near sunset, the night is very calm, and towards the morning an Easterly breeze is not unfrequently felt.

The cause of the hot winds ceasing with sunset seems to be the great depression of temperature during the night, coinciding with the Westerly direction of the wind. In consequence the wind meets, soon after sunset, with surfaces covered with a stratum of air cooled by the vicinity of the radiating surface of the ground; the hot wind passes over this stratum and is therefore not felt near the surface.

It is only during the middle, and towards the end of the hot season, that the hot winds blow till 2 or 3 o'clock in the morning, when the rains stop them suddenly.

The hour of the day at which the hot winds *commence*, is variable from the beginning to the end of the hot season. In the first months they begin to blow at 12 or perhaps 1 P. M., then the period becomes gradually earlier, till a short time before the rains they begin at 6 or 7 A. M., leaving only a few calm hours in the very early part of the morning.

The quantity of carbonic acid in the air during the hot winds is very small. It reached, in an experiment at Allyghur,* scarcely $\frac{1}{100}$ part

* The quantity of air examined was 50,000 cubic centimetres, the increase of weight of all potassium tubes reached was not a full milleogramme.

in 10,000 parts of air, the ordinary quantity being 3.5 to 4 parts in 10,000.

Geological Observations.

Of the valley of the Brahmaputra, a detailed map has been prepared, showing the different soils, with observations on former levels and beds of the river, and depths from the surface deposits to the sub-soil. Different coal localities in the Bhootan Himalayas, and in the Naga Hills, have been examined and entered in this map.*

These observations, compared with the examinations of the different soils of the Delta of the Ganges, show that the valley of the Brahmaputra differs from the Delta in being covered with lacustrine deposits, occasionally varied by the coarse gravel brought down by the Himalayan Rivers on its North-Eastern side.

The course of the actual Brahmaputra, originally flowing in the bed of the Lohit, (which was the original name used in this valley,) has not been altered by a sudden change of its bed, but has gradually shifted itself; the deposits made on the right bank (where all lacustrine soil is carried away and replaced by the actual deposits of the river) being very different from the clays on the left.

In the Himalayas, along the North-East side of the Brahmaputra, the coal is found in small seams of sand-stone alternating with strata of conglomerates of pebbles (Nageflue,) the pebbles being remarkably smaller than the deposits of the present rivers.

To these sedimentary rocks succeed, at a short distance from the banks (much shorter than in the Western Himalayas,) crystalline hornblendic rocks, chiefly hornblendic gneiss, with a peculiar linear arrangement of quartz nodules succeeding each other, when seen, in the proper section, like beads on a string.

The dip of the stratification in the sand-stones and conglomerates, which form the outer ranges of the Bhootan Himalayas, is very well defined by the alternation of the finely grained sand-stones with the conglomerates.

The dip of the strata is North 30 degrees to 40 degrees West, inclination 55 degrees to 65 degrees.

* This map, in four sheets, scale four miles to an inch, has been sent with my manuscripts to the Hon'ble the Court of Directors.

In the crystalline hornblendic rocks, the cleavage, which is well developed, dips also in the same direction. The mean direction of this dip was also found North 30 degrees to 35 degrees West, inclination 55 degrees to 60 degrees.

It is deserving of remark, that this dip of stratification and cleavage planes are quite analogous to the direction of dip in Sikkim and the Western Himalayas of Kumaon and Gurhwal. In all these parts of the Himalayas the dip of the cleavage is chiefly Northerly, varying in different parts to the East or to the West.