P.S. 27th June, 1863.—Since the foregoing communication was made to the Geological Society, I have received a copy of Dr. A. Oppel's 'Palæontologische Mittheilungen,' Stuttgart, 1862.

The first part of this most valuable work is devoted to a description of Macrurous Crustaceans of the Jurassic formations of Germany, &c., and is illustrated by 38 excellent plates. The author has, I observe, adopted Germar's generic name of *Mecocheirus* in his descriptions of the Solenhofen *Crustacea*.

Although Dr. Oppel has added more than 50 new species to the list of Jurassic *Crustacea*, none of them agree, even generically, with that just described from the Lias of Lyme Regis.—H. W.

EXPLANATION OF PLATE XI.

Scapheus ancylochelis, H. Woodw., four-fifths the natural size.

APRIL 1, 1863.

S. N. Carvalho, Jun., Esq., 6 Aberdeen Park, Highbury Grove, N., and William Edwards Wood, Esq., Tamworth Castle, Tamworth, were elected Fellows.

The Rev. Dr. O. Heer, Professor of Botany in the University of Zurich; Sign. P. Savi, Professor of Geology in the University of Pisa; Sign. G. Ponzi, Professor of Comparative Anatomy and Physiology in the University of Rome; Dr. J. Leidy, Professer of Anatomy in the University of Pennsylvania; Il Marchese Pareto, of Genoa; and Professor A. Daubrée, of the Jardin des Plantes, Paris, were elected Foreign Correspondents.

The following communication was read:—

On RECENT CHANGES *in the* DELTA *of the* GANGES.

By JAMES FERGUSSON, Esq., F.R.S.

[Communicated by the President.]

[PLATE XII.]

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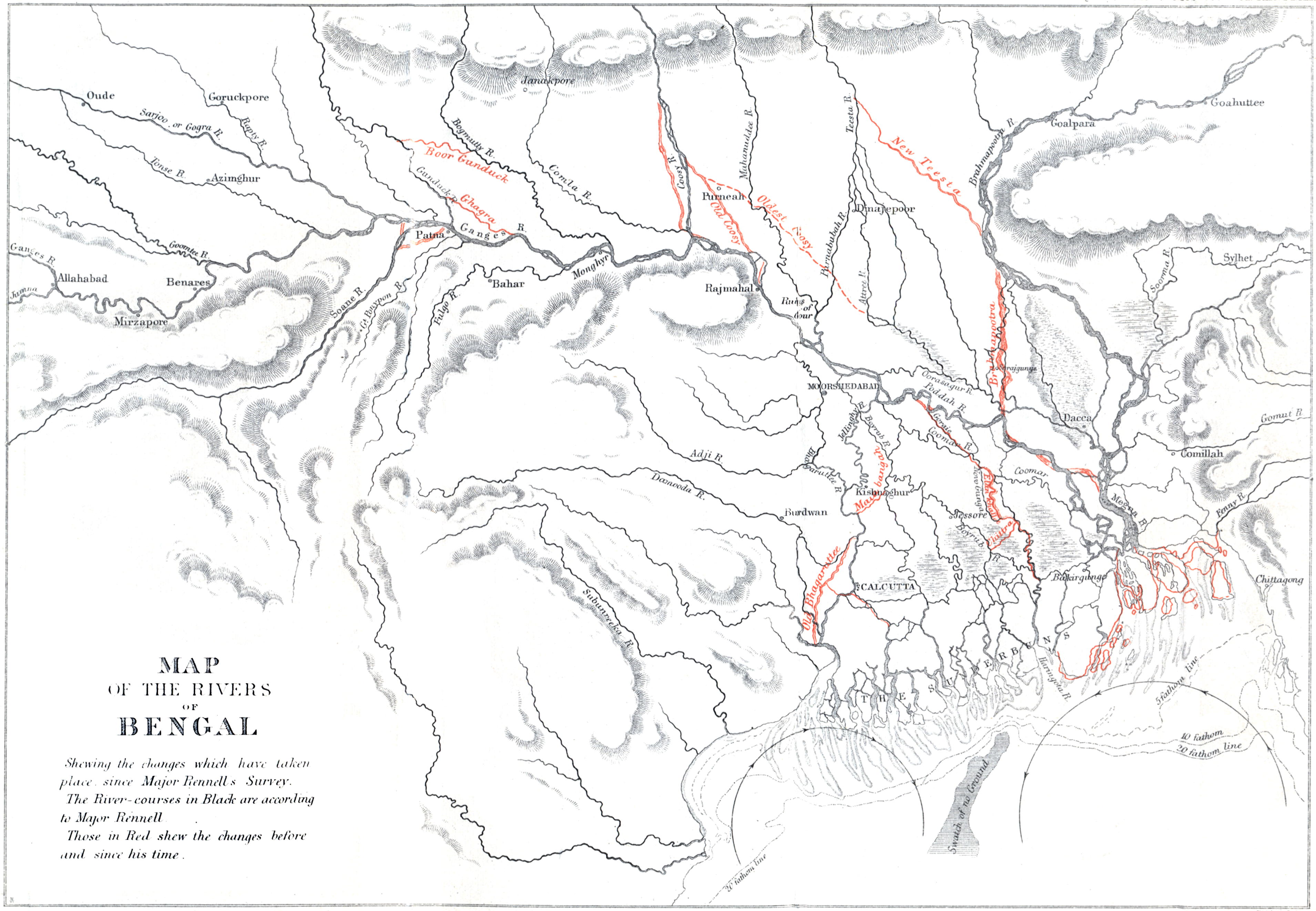

MAP
OF THE RIVERS
OF
BENGAL
Shewing the changes which have taken place since Major Rennell's Survey.
The River-courses in Black are according to Major Rennell.
Those in Red shew the changes before and since his time.
Oude
Goruckpore
Janakpore
Goahuttee
Goalpara
Sarjoo or Gogra R.
Rapty R.
Tonse R.
Azimghur
Boor Gunduck
Gunduck R.
Ghagra
Bogmutty R.
Comla R.
Coosy R.
Old Coosy
Purneah
Oldest Kosy
Mahanuddee R.
Teesta R.
New Teesta
Brahmapootra R.
Dinajepoor
Patna
Ganges R.
Goomtee R.
Ganges R.
Allahabad
Jumna
Benares
Mirzapore
Soane R.
Gt. Punpun R.
Bahar
Monghyr
Rajmahal
Ruins of Gour
Sylhet
Soorma R.
Falgo R.
Attree R.
Brahmapootra
Serajgunge
MOORSHEDABAD
Oorasagur R.
Poddah R.
Dacca
Gomut R.
Comillah
Adji R.
Dumoda R.
Burdwan
Kishnaghur
Jessore
Coomar
Megna R.
Fenny R.
Chittagong
Bakirgunge
CALCUTTA
Hooghly
Subunreeka R.
THE SUNDERBUNS
Huringotta R.
5 fathom line
10 fathom
20 fathom line
Swatch of no Ground
20 fathom line

W. West. Lith.

I. *General Considerations.*

1. *Introduction.*—It may seem presumptuous in one who is neither a geologist nor has any pretension to geological knowledge to venture to address this Society on a subject so nearly akin to their special science. My excuse must be that, having resided for five years on the banks of one of the most active of the Bengal rivers, I have had opportunities which are not vouchsafed to every one of observing their phenomena, and have been a witness of the changes I am about to describe. I may also, perhaps, be allowed to state that, when I first became aware of the disturbance that was taking place around me, I set myself carefully to measure and observe what was passing; and, in 1835, made a sketch-survey of the lower Ganges and Brahmapootra, from Jaffiergunge to the sea. This was published by Mr. Tassin a few years afterwards, and is, so far as I know, the only survey that was made—certainly the only one published—between that made by Major Rennell and the survey now in progress, but which has not yet been given to the world. I may also mention, in extenuation, that I have waited for more than a quarter of a century in order that some one more worthy might undertake the task; but, as no one has come forward, I may perhaps be now excused for venturing upon it.

In order, however, to obviate the reproach of presumption, my intention is to confine myself wholly to the historical period, and practically to the time that elapsed between the survey made by the celebrated Major Rennell, between the years 1780–90, and the survey now in progress; and though I shall be obliged, occasionally, to mention facts that may have occurred before the Christian era, they will be only such as are based on human evidence, and not such as properly fall within the domain of the geologist.

2. *Oscillation of Rivers.*—Before describing the actual phenomena, it may be necessary to call attention to certain principles—not very recondite, perhaps, but indispensable to a clear understanding of what is to follow.

The first of these is:—

All rivers oscillate in curves, whose extent is directly proportionate to the quantity of water flowing through the rivers.

An inspection of any good map is sufficient to prove the general correctness of this dictum, but its consequences have been strangely overlooked both by engineers and potamologists. Without attempting to enter into the theory of the question, it may be sufficient for the present to state, in illustration, that the action of rivers appears to be the exact converse of that of the pendulum.

The pendulum is a body in stable equilibrium, whose natural condition is consequently that of rest, and, being once disturbed, it seeks to regain that position; but, the original force remaining, it would go on oscillating for ever if we could abstract all the natural conditions of friction, resistance of the atmosphere, &c.

A river, on the contrary, is a body of water in unstable equilibrium, whose normal condition is that of motion down an inclined plane; and, if we could in like manner abstract all the natural

conditions of inequality of surface or of soil, it would flow continuously in a straight line; but any obstruction or inequality whatever necessarily induces an oscillation, and, the action being continuous, the effects are cumulative, as those in the pendulum are discumulative; and the oscillation goes on increasing till it reaches the mean between the force of gravity tending to draw it in a straight line, and the force due to the obstruction tending to give it a direction at right angles to the former.

If this be so, it will immediately be perceived that the extent or radius of the curves will be directly proportioned to the slope of the bed of the river. If, for instance, a river were flowing down a regular slope, through a perfectly homogeneous soil, with a fall of, say, 10 feet per mile, or 1 in 500, the curves would be so extended as to appear nearly a straight line on the map. With a fall of 1 foot per mile, the radius of the curve is, as nearly as I can ascertain, double that of a river with a fall of 6 inches; and when the fall is about 3 inches per mile, the direct and tangential forces so nearly balance one another that the curves are practically semicircles. In the latter case the chord of the curves is practically four times the width of the river. Thus a river 1000 feet wide would oscillate once in 4000 feet in the general direction of its course, and the extent of its curve, measured along the centre of the stream, is a little more than 6000 feet. Between a fall of 6 inches and 1 foot per mile, the oscillation is, apparently, once in about six times the width; above a foot it rises to one in ten or twelve, above which it is extremely difficult to find examples uninfluenced by natural obstructions. It need hardly be remarked that these observations apply to rivers when their beds are full, which is the only time when they are shaping their courses *.

There are a number of other consequences flowing from these, to which I shall not allude here, as they have no direct bearing on the subject in hand, though it would be extremely interesting if they were observed and tabulated; for not only would these tables enable any one on inspecting a map to calculate approximately the slope of a country, and to estimate the relative importance of every river there delineated, but they would enable the engineer to regulate their courses, and the statistician to predict the result of the changes he sees taking place. To make this clearer, let me take one example. The Austrian engineers have of late years spent enormous sums of money in the attempt to straighten the course of the Danube by cutting off its lateral branches. This has been done by embanking across their mouths with dykes of fascines and piles. For a time this resists, and might resist so long as the river finds some other place where it can readjust its curvature; but, as these are stopped one after the other, it bursts through the barriers and resumes its old course. The fact is, the Austrians are trying to make the whole body of water flow in curves due only to a portion, and they have hitherto, as might be expected, found this impossible; had they taken the trouble to calcu-

* The average width of the Nile between Koum Ombos and Memphis is

late the curve due to the whole body, a few simple groins would have sufficed for all their purposes. It is precisely the same question as if it were proposed to make a 10-inch pendulum beat seconds, or one 39 inches long beat once in two seconds. It can be done by main force, but the moment the pressure is removed or weakened the pendulums resume their natural beat; and a clockmaker who constructed his clocks on this principle would fail as certainly as the Austrian engineers.

3. *Elevation of the Banks of Rivers.*—The second point to which I wish to call attention is the tendency of rivers in alluvial soils, especially in deltas, to raise their banks, and so confine themselves in their beds.

This process has been well described by Sir Gardner Wilkinson as regards the Nile, and by Sir Charles Lyell for the Mississippi; but neither of these gentlemen appear to me quite to have caught, or at least explained, the true cause. As regards the Ganges certainly, and the other rivers so far as I can judge, it is owing to the existence of great sheets of still water in the low lands beyond the banks of the rivers. These, being still, have deposited their mud, if they ever had any in suspension; and being too massive to be set in motion by the rivers, they reduce the flowing streams to inaction the moment

2000 feet; the average length of oscillation 8500 or 4·25. The slope about 6 inches per mile. The following Table gives the approximate extent of the oscillation of the Ganges and the three Kishnaghur rivers.

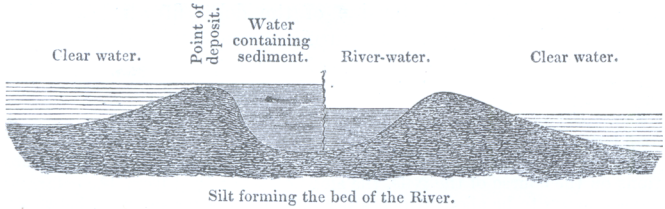
	Distance, direct, in miles.	Distance, per river, in miles.	Width of stream, low water, dry season, in feet.	Number of oscillations.	Length of oscillation, in miles.
GANGES.					
Allahabad to Chunar	62	104	3500	17	3·7
Chunar to Buxar	80	113	4000	20	4·
Buxar to Patna.....	74	96	5000	15	5·
Patna to Monghyr	82	106	6000	11½	7·
Monghyr to Rajmahal.....	96	108	7000	10	9·5
Rajmahal to Rajapore	90	100	7000	10	9·
Rajapore to Pubna	30	44	4000	6	5·
Pubna to Jaffiergunge	32	36	3000	8	4·
BHAGARUTTEE.					
Chokah to Nuddya	96	120	1200	62	1·5
Nuddya to Chogdah	24	30	2000	9	2·5
Chogdah to Calcutta.....	34	42	3000	11	3·
JELLINGHY.					
Jellinghy to Nuddya.....	50	112	1000	42	1·2
MATABANGAH.					
Ganges to Coomar	18	28	1500	9	2·
Coomar to Kissingunge ...	30	50	800	46	⅔
Kissingunge to Chogdah ...	24	29	500	47	½

they leave their beds, and consequently force them to deposit their silt in their immediate proximity.

The first consequence of this is, that water resists water far better than earth does. A river can attack its banks in detail, can eat them away bit by bit, and carry off the spoil; but the still water, seizing the silt, forces the river to deposit it exactly where it is most useful in forming a barrier against further incursions, and so finally repels its advance.

In India these backwaters are called jheels, and are large sheets of clear water existing during the cold weather at about the same level as the river. During the rains they rise nearly *pari passu* with the rivers, partly owing to the quantity of rain-water that drains into them, partly to leakage through sandy strata, partly to small creeks or openings from the rivers, and partly also from almost all of them being open at their lower ends, so as to feel the reflex of the inundation. From all these causes, when the river is at such a height as to overtop its banks, it meets this body of still water (fig. 1), and, not being able to set it in motion, it deposits its silt in the limit between the moving and the still bodies. Even when the jheel has not risen so fast as the river, a few days' overflow serves to restore the equilibrium, and then the deposition goes on as before. In most parts of Bengal indigo-planters and others avail themselves of this interval to cut canals, or khals, through the banks, in order that the river-water may flow into the jheels, and so raise their beds and render them fit for cultivation. Even under the most favourable circumstances, however, the action seldom extends more than 100 or 200 yards from the banks; and, when the equilibrium of water is restored, the silt is deposited in the canal, which requires consequently to be cleared out every year, and after a few years the deposit beyond has raised itself to the height of the bank, so that further progress in that direction is impossible, and the opening in the bank of the river is then soon completely obliterated.

Fig. 1.—*Diagram-section across the Bed of a River.*



It is extremely difficult to fix the exact point at which this deposit begins to take place; but, as far as I have hitherto been able to ascertain, rivers flowing through a country whose slope is more than 6 inches in a mile have rather a tendency to deepen their channels and abrade their banks, and the land in their immediate proximity is lower than at a little distance*. At 3 inches in the mile, or

* The fall of the Indus from Attock to the sea being on an average 1 foot per

under this, the deposit always takes place; and its extent is nearly in the inverse ratio to the slope.

The exact turning-point of the two systems still remains to be fixed; but my own impression is, that we are not far wrong in taking 6 inches as the limit at which the deposit begins to take place; in many instances, however, 5 or even 4 inches may be taken as the starting-point*.

4. *Secular Elevation of Deltas.*—The only other point to which I will venture to call attention is what is called secular elevation, which I shall endeavour to define.

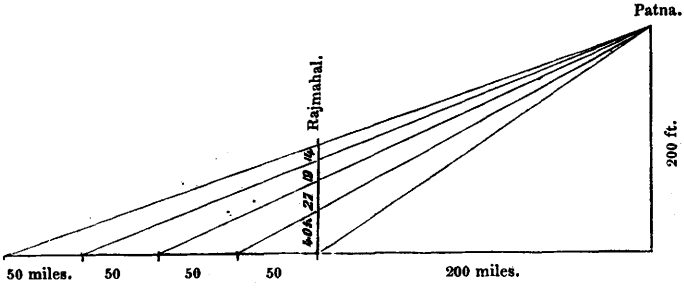
There was a time, before the formation of the Deltas of the Nile and the Ganges, when the sea or tide extended to Memphis in the one case, and to Rajmahal in the other. If at that time the slope of these rivers had been measured from any fixed point, such as the cataracts in Egypt in the one case, and the rock of Chunar in the other, it would have been found that the slope of both of them was very much greater than it now is, it having been diminished in the exact ratio in which the ground at the apex of the deltas has been raised—about 80 feet at Rajmahal, and 60 feet at Memphis. Little or no silt was consequently deposited in the up-country in early times, but everything was swept to the sea, and the extension of their deltas has consequently been in an immensely more rapid ratio than at present. But, besides this, for every mile that the delta extended seaward, the slopes, as shown on the diagram (fig. 2), would tend to become parallel in a geometric, and not in an arithmetical, ratio. And when the elbows at Memphis and Rajmahal were completely obliterated, the secular increase must have been infinitesimally small.

Taking first only the mathematical view of the subject—if we assume a point such as Patna, say 200 miles above Rajmahal, and that the delta is now extended 200 miles below that point, assuming also that Patna is now 200 feet above the level of the sea, and Rajmahal 100 feet, all which figures are sufficiently correct for illustration, it is evident that, if we divide the time since the sea was at Rajmahal into four equal epochs, the level at Rajmahal during the first period of the extension of the delta fifty miles seaward would have risen 40 or 42 feet, during the next 27, during the third

mile, it is not a depositing river. The only part of its course where the slope is less, judging from the lateral extent of its oscillation, is between Kyrpore and Sehwan. Between these places it may deposit to some extent, but elsewhere its course is steep and straight.

* No argument on this subject can be depended upon if derived from observations on the course of the Nile, the slope of whose bed from the cataracts to the sea appears to be about 6 inches per mile, for the reason that, between the bank of the river and the hajar, or desert, the natives have at different times constructed numerous causeways, as may be seen in the atlas prepared by the French savants in the beginning of this century, and explained by Sir Gardner Wilkinson (Journ. Royal Geogr. Soc. vol. ix. p. 432 *et seq.*). These act as so many dams or silt-traps during the inundation or depositing season. But for these dykes, it is by no means clear that there would have been any deposit in recent times on the plain of Thebes, instead of 7 feet in 1700 years, which Sir Gardner calculates; and the variation in the thickness of the deposits in different places seems to be almost wholly due to these artificial obstructions.

Fig. 2.—*Diagram illustrating the Secular Elevation of Deltas.*



20, and during the last 13 or 14, or less than one-third of what was due to the accumulation during the first period. But this is far from representing the whole truth; first, in consequence of the greater quantity of silt brought down by the river when its slope was 12 inches, which it must have been during the first period, instead of less than 6 inches as it is now. And, secondly, the area or breadth of the delta is necessarily less near its apex than at its base, and, consequently, the area over which the silt had to be deposited much less than at present.

From these and other minor causes I feel convinced that if we assumed the deposit to be 50 feet, or one-half, during the first period, it would be rather under than over the mark; and, say, 25 feet during the second, 12 or 13 during the third, and 5 or 6 during the last of the four periods indicated in the diagram. From the conformation of the ground I should be inclined to assign a higher rate of progression for the rise of the land of Egypt in the neighbourhood of Memphis. But it is difficult to speculate on the phenomena of that river while we remain so ignorant of the physical condition of the country from which the inundation proceeds. But even more uncertainty has been superinduced, as pointed out above, by artificial obstructions.

All this is assuming that the silt is distributed quite evenly over the whole delta. This, however, is practically very far from being the case. The mode in which deltas are raised is by a river, flowing through some low part of the country, gradually embanking itself, and then raising its bed till the body of its water is higher than some neighbouring region; it then falls into this, and, going through the same process, it fills that depression, and then goes on to the next. After a long cycle of years it comes back again to the country it first left, which probably has not risen 1 foot since, while the neighbouring country may have been raised 30 or 40.

From these data it will be perceived how fallacious any conclusions must be which are drawn from borings into the strata of deltas, and calculations formed from local superficial deposits. I myself have seen the bricks which formed the foundation of a house I had built carried away, and strewed along the bottom of a river at a depth of

30 or 40 feet below the level of the country. Since then the river has passed on, and a new village now stands on the spot where my bungalow stood, but 40 feet above its ruins; and any one who chooses to dig on the spot may find my "reliquiæ" there, and form what theory he likes as to their antiquity or my age. If we add to this local disturbance the varying degree of elevation just pointed out in the secular increase, it must be seen that the problem is of a much more complex nature than has hitherto been assumed.

5. *Mode in which Deltas are elevated.*—Independently of the changes wrought by the varying quantity of water in the different branches of the deltaic rivers, and the consequent necessity for enlarging or contracting the extent of their oscillations, there is another class of changes superinduced by the accidents to which so complicated a system must always be liable. If one of the tributaries, for instance, which before fell into the hollow side of a curve presses on the convex side, if a sand-bank is formed anywhere, or if any natural or artificial obstruction forces the river to change its bed in any part, the whole system is so rigid that the alteration is felt in every direction, both above and below, as far as the alluvial plain extends.

One consequence of any such alteration in the course of the main stream is, that the initial or terminal oscillation of any tributary or distributary is continually altering its position, and the oscillations cut their way through the whole plain * of the river, both in an upward and downward direction.

Such a river as the Ganges between Patna and Rajmahal must have eaten through its plain several times since it has occupied its present position. But when the delta is so raised as to reduce its slope from 6 to, say, 3 inches per mile, it is not difficult to foresee a time when the river will so raise its bed as to be obliged to seek a new "plain" further north, and may again resume the position it once occupied in the centre of its valley, but from which it has been forced against the southern hills, by the greater "*vis viva*" which the Himalayan streams derive from the rapid slope of their beds and their preponderating body of water.

None of the rivers of the delta have in historical times, so far as we know, worked their way twice through the same plains. The first operation so raises their plains that they generally find it easier to seek a new course in the lower lands on either hand; and the stream in their old beds consequently becoming sluggish, they gradually silt up and become, after a while, altogether obliterated, except here and there where a reach has been cut off in the process, and remains, like a fossil, to mark the previous existence in that spot of a river of a given oscillation, which may still be measured with perfect certainty in the fragment that is left. It is by this continual shifting of the plains of rivers that the whole delta is gradually raised to a higher level.

* By "plain" in this sense is meant the district occupied by the river between the extreme outward edge of its oscillations on either side. With a river 1000 feet wide, its plain may extend from one to two miles in width, and others in like proportion, varying, of course, according to the slope of the country.

This is a curious and complicated process, which I shall now try to make as clear as I can, by describing the phenomena as they have occurred in the valley of the Ganges.

II. *Physical Changes in the Valley of the Ganges.*

1. *Upheaval of the Madoopore Jungle.*—Although the principal object of this paper is to describe the phenomena resulting from the deposit of silt by the rivers of Bengal, there is one of a contrary nature which has had so marked an influence on the river-systems of the delta that it is impossible to pass it over. The circumstance I allude to is the upheaval of a large tract of country known as the Madoopore Jungle, which there is every reason to suppose took place in very recent times.

This tract extends for about seventy miles due north from the city of Dacca, which is built on its southern extremity. Its greatest width in the centre is about thirty-five miles. On its western face it has a well-defined boundary, and rises in hillocks to a height of about 100 feet from the level of the alluvial plain along its whole length; in the centre its average height is from 40 to 60 feet above the plain, and it gradually slopes away to the eastward, dipping below the old bed of the Brahmapootra, and losing itself in the Sylhet Jheels.

The surface of this district is a hard ochreous clay, identical, so far as I can judge, with the strata found below the peat and recent deposits at Calcutta, where it exists at a depth of from 70 to 120 feet below the surface of the soil.

There is, at all events, no *à priori* improbability against this upheaval having occurred in very recent times. An inspection of the map will show that it occurred in the axis of the belt of volcanic action which extends from Narcondam through Barren Island on to Cheduba and Ramree, and thence to Chittagong and Dacca.

Without going further back than the great earthquake which occurred at Chittagong in April 1762*, I may remind the Society that a large tract of land was then submerged, that other parts were elevated, that two volcanos broke out, and the whole settlement was shattered, and that at Dacca the shocks were so violent that the wave from the river swept off a large number of the inhabitants.

It was not then, however, that any upheaval took place, nor at any period subsequent to the foundation of that city in the beginning of the seventeenth century by Jehanguire; for its oldest buildings, though cracked, are not destroyed, as they would have been by such a convulsion. And how long before that time it occurred we can only guess by trying to estimate how long it would take the Brahmapootra to fill up the Sylhet Jheels to the extent it has done, and by the uncertain light of native traditions, some of which will be alluded to in the sequel.

As hinted above, there exists to the eastward of the upheaved region a depressed area of about equal extent. For a description of this I cannot do better than refer to Dr. Hooker's 'Himalayan

* Phil. Trans. vol. liii. p. 251.

Journals' (vol. ii. p. 256). He sailed for some days among these Jheels, and found by his barometric levellings that they were very slightly raised above the Bay of Bengal. Their bottom generally consisted of accumulations of decaying vegetable matter—incipient peat—through which he could not reach a bottom by thrusting in the boat-poles.

It is not necessary here to insist on this depression being the effect of the upheaval of the Madoopore Jungle, or to inquire whether it pre-existed; but I think there can be very little doubt that the disturbance caused by the upheaval was what turned the Brahmapootra towards the east into these jheels.

A mere inspection of the map is sufficient to establish the probability that this change must have taken place not very long ago; and though the length of the course of the Brahmapootra is only half that of the Ganges (for it is not clear that it has any connexion with the Sampo of Tibet), still the two rivers are quite equal in volume, inasmuch as both enter the deltaic plains of Bengal with a ten-mile oscillation before parting with any of their waters through their distributaries below Rajmahal on the one river, or at Rangamutty on the other.

Although equal in volume, the Brahmapootra brings down an immensely greater quantity of silt than the Ganges—probably one-half more; as Buchanan Hamilton phrases it, "It is the dirtiest river I ever saw." This arises, principally, from the fact that the slope of the valley of Assam, from Sudya to Goahuttee, appears to be more than 6 inches per mile. The consequence is, that neither the principal branch of the Brahmapootra nor any of the tributaries deposit their silt, but all is swept onwards; and, owing also to the greater quantity of rain that falls there than falls to the westward, the denudation of the land is much more rapid. This condition of matters will not be changed till the section across the valley opposite Goalparah has been considerably raised beyond its present level, or, in other words, till the land between Goahuttee and Goalparah attains an elevation corresponding to that attained in the valley of the Ganges about Rajmahal. At present the elevation of the river at Goahuttee, with 350 miles to run, is apparently lower than the Ganges at Rajmahal, within 250 miles of the ocean*.

Until this extra elevation takes place, the physical condition of the valley of Assam will so closely resemble that in which the valley of the Ganges probably was when the sea was at or near Rajmahal, that few problems connected with this subject would be more interesting than to compare the condition of the two valleys, in so far as materials exist for the purpose.

At that early time the River Ganges must have flowed with greatly increased velocity nearly in the middle of its valley; but as its slope and consequent velocity decreased, it was pushed southward against

* The level of the river at Goahuttee is assumed from a long series of barometric observations, checked by those of the brothers Schlagintweit ('India,' vol. ii. p. 103); that at Rajmahal, from the levels of the East Indian Railway, checked by those of the great Trigonometrical Survey.

the hills by the greater energy of the northern streams, and the mass of their accumulations, the only southern stream of sufficient power to keep it off its hills being the Soane.

The Brahmapootra still maintains itself nearly in the centre of its valley for the greater part of its course, but it must be pushed southwards, as the Ganges has been, in the exact ratio in which the quantity of water flowing from the Himalayas exceeds that draining from the southern hills; and, as this takes place, the valley must rapidly be filled up and become habitable, which it hardly can now be said to be in most parts.

Though it is dangerous to descend to particulars in such matters, my impression is that hardly more than 4000 or 5000 years have elapsed since the sea, or rather the tide, was at or near Rajmahal; or, to speak more correctly, since the greater part of the province of Bengal Proper was a great lagoon, like those which exist at the mouths of the Brenta or the Po, or the Lakes Mensaleh and Boorlos, at the mouths of the Nile: for there is no reason to suppose that there did not always exist—in historical times at least—a bar or barrier where the tides turned somewhere very near where the Sunderbuns now are; but between this and the apex of the Delta all seems to have been a tidal swamp. When this was the case, the upper valley of the Ganges was in the semi-habitable state in which we now find Assam; and I fancy we can, in history, trace the settlements that were made one after another, proceeding eastward as the Delta extended, and, by its elevation, diminished the slope of the bed of the Ganges to what we now find it.

2. *The Silting-up of the Sylhet Jheels.*—To return, however, to the Sylhet Jheels. When the Brahmapootra was first turned into them, they consisted of an immense tract of submerged country, covered with clean still water of no great depth, and consequently every particle of silt that was brought into them was seized upon and deposited; and the Luckia and Megna, which flowed out of them, must then have been, as they are now, clear and pellucid streams, as compared with the turbid waters of the two great rivers.

The first effect of this invasion, that we trace on the map, is that the Soorma and other streams which flowed from Munnipore due westward, along the foot of the Cossya Mountains, were deflected southwards, which it was easy enough for the great river to do, so long as it could take them in detail. It was not until they were all united in the bed of the Megna, and pressed between the Tiperah Hills and the upheaved tract, that the real struggle began.

In this case, though the Megna was much the smaller river, it had certain advantages necessary to be pointed out in order to appreciate the result.

The first of these is, that the Sylhet rivers depend wholly on the monsoon rains for their supply. The clouds, striking early on the Cossya range, discharge their waters with a violence hardly found elsewhere; and, as is well known, from 500 to 600 inches of rain fall on the slopes of these hills during the three months of the rainy season. It may also be mentioned that, owing either to the nature

of the rocks of which these hills are composed, or because the violence of the monsoon has long ago denuded them of every moveable particle, these rivers bring down little or no silt even in the height of the monsoon, and are quite clear in the cold weather.

The Brahmapootra, on the other hand, depends for its floods partly on the melting of the snow, partly on the far more moderate and later rains of the valley of Assam, probably hardly exceeding 100 or 120 inches; having also a longer course to run, it arrived later at the scene of the struggle, and found the country already occupied by the waters of the Megna to such an extent as to be able to dam back its waters for the first month of the rains, and to force it to deposit its silt in its own bed. It could not, of course, have done this with any effect until the large river had reached the higher lands beyond the jheels to the southward, and with its silt had bridged across the whole width of the jheel-country, and, by this process, had embanked itself along the whole extent, so as to make it difficult for it to change its course. So long as the Brahmapootra was only forming an inland delta in the depressed country, the Megna had no hold upon it; but when it came to flow in what was practically an aqueduct, along the top of an embankment of its own making, it was rendered powerless, and the struggle was soon over. Had it not been for the upheaved tract already alluded to, it would, of course, have sidled away westward, and so have avoided the contest with the Sylhet rivers; but that being impossible, we find it retracing its steps nearly seventy miles northwards, and finding a new channel for itself above Dewangunge in the bed of the Jennai.

3. *Eastern Gap in the Seaward Face of the Delta.*—Before leaving this branch of the subject, it may be well to allude to another geographical fact, which I believe to have been in a great measure the result of this diversion of the Brahmapootra into the Sylhet Jheels. It is the great gap or gulf that exists to the eastward of the Gangetic half of the delta.

From the Hoogly to the Horringotta the seaward face of the Sunderbuns is tolerably level and fixed; at all events, it has undergone no sensible change within any period to which our knowledge extends; and, so far as can be ascertained, it shows no tendency to go forward. In that portion of the delta, however, allotted to the Brahmapootra a great deal of work has yet to be done; everything there is so new, and in such a constant state of change, that, even in that climate, vegetation has not been able to settle upon the islands, and these are continually moving and changing their places. A great deal has been done to fill up the gap since the Brahmapootra last changed its course, in the beginning of the present century; but we want a new survey to be quite sure to what extent this has gone. If I am correct in my view, that the gap is mainly the result of the straining of the waters of the Brahmapootra through the Sylhet Jheels, and their consequently reaching the Bay of Bengal deprived of all their silt, it follows that the process of filling up will now be comparatively rapid, and that the eastern face of the delta will assume before long the same fixed character which

now marks that of the western portion, and which is due—as will be afterwards explained—to the joint action of the tidal and fluviatile forces which meet at that point.

4. *Change in the Bed of the Brahmapootra.*—It would have been extremely instructive if the progress of the struggle between the Megna and the Brahmapootra had been carefully watched and recorded; all we now know is, that when Major Rennell surveyed these rivers in 1785, neither he nor any of his assistants had any idea that the Brahmapootra had not always flowed, and would not always continue to do so, in the channel in which he then found it. We now know that, though a considerable body of water may flow that way in the rains, yet during nine months in the year a creek, or rather chain of ponds, 100 or 200 feet wide, and everywhere fordable, represents the river that a little more than half a century before flowed through that country in seven-mile reaches, and with a breadth of more than a mile and a half even in the dry season.

It is unfortunate that Buchanan Hamilton* did not visit this country when surveying the neighbouring districts in 1807–10, as the change must then have set in; and his greater knowledge of the language and of the customs of the natives would have led him to remark upon the anomaly of the smaller stream (the Megna) giving its name to the Brahmapootra, from their junction at Sonerampore to the sea, proving that the bed belonged to the smaller river, and that it had been invaded by the larger; and proving also—for this class of evidence is very cogent in these regions—that the invasion had taken place after the country had been sufficiently inhabited and settled to have the names of its rivers fixed on the bases they now maintain. So far as we can judge from appearances, this could hardly have occurred very long ago.

When the survey now in progress is completed, it will not be very difficult to estimate this epoch approximately. The first thing to be ascertained is, of course, the quantity of silt brought down by the Brahmapootra; then to estimate the area of the Sylhet Jheels filled up by the great delta formed in them by the waters of the Brahmapootra, checking this with the area of the delta at the mouth of the Megna, which remains to be filled in; and, with a few borings, all this ought not to be very difficult. In the meantime, it certainly is to be regretted, in an economic point of view, that the combined Sylhet rivers prevailed in this struggle. They cannot fill up their own swamps, because they possess no silt; and they shut out the only river that is capable of doing it for them. Now, however, every year must make their condition worse; for, as the delta extends, the land between them and the sea, below Dacca, must rise, and they consequently must deepen, and their water spread, until the whole province may become a submerged peat-factory, from which fate nothing can save it but inviting back the river they have just expelled.

5. *Opening of the R. Jennai.*—The first river the Brahmapootra met which could afford it a means of escape was, as just mentioned, the

* His surveys, in a mutilated form, were published in 3 vols. 8vo, by Montgomery Martin, in 1838.

Jennai. Having no earlier maps than those of Rennell, it is impossible to be certain what the condition of this river was before he surveyed it. He found it flowing due north and south, in one-mile oscillations, with a breadth of between 400 and 500 yards, and flowing so regularly that I cannot help suspecting that it was then a very young river; if I may be allowed to guess, I should say not more than twenty years old. In fact, it seems to have been the first product of the struggle between the Megna and the Brahmapootra, and did not exist till the waters of the latter river had been dammed back so as to flow in this direction.

When Buchanan Hamilton visited this country in 1810, he merely remarked that the Brahmapootra threatened to "carry away all the vicinity of Dewangunge" (which it has since done), "and perhaps to force its way through the Konnai (Jennai) into the heart of Natore."*

It was not, however, till ten years later that it had increased to such an extent as to affect the Jessore rivers; and it was not till about the year 1830 that any reliable information was obtained regarding it. About that time a party of engineer officers was sent to connect Assam with the Great Trigonometrical Survey then in progress in Bengal. They carried a series of triangles up the bed of that river; and it was at the same time attempted to navigate it with steamboats. Nothing, however, was published until the river was laid down on a map of Bengal which I constructed, in conjunction with the late Mr. Tassin, on a scale of eight miles to one inch, in the year 1836. At that time it was flowing through Natore with an oscillation of nearly seven miles, and has continued to do so ever since; for though in its oscillations it sweeps away hundreds of miles of land every year, it is only very lately that it has shown any restlessness, or any tendency to leave its present direction, and whether it will be successful or not in so doing still remains to be seen. In the meanwhile the river is *nearly* where it is shown on the map; but, as it was there in 1850–53, it certainly is not there now, as it never is exactly in the same place for two successive years, being young and active, and roaming through a new and unconsolidated country. It may also be mentioned that the city of Serajgunge—the largest and most important mart in that part of the country—is somewhere in that neighbourhood now, but not where marked on the map, of course, as it is annually obliged to accommodate itself to the vagaries of the stream, and change its locality. It may be ten miles further up the stream, or ten miles further down, or five miles further east or west; but it is somewhere thereabout; and that is all the information geographers can hope for in a country where land can only be classed with floating capital.

6. *Jessore Group of Rivers.*—The first result of this invasion of the Gangetic territory by the Brahmapootra was, that it should seek to re-enact the part which had just been performed on the other side of the Madoopore Jungle and should threaten to shut up the Ganges, and send it back through its own distributaries. It was so nearly successful that, in 1838, the Great Ganges was fordable at

* Martin, vol. iii. p. 396.

several places above the junction. As the Brahmapootra has an oscillation of seven or eight miles, while the Ganges has only one of five miles at that place, and as even that is gradually diminishing, it must have been successful if the Ganges had been able to find another outlet. This, however, was not so easy, the whole of the country to the southward and westward having been traversed repeatedly by powerful rivers, and the country consequently well raised and consolidated.

The Chandna was the first river it met above the junction, from which it could look for relief. This river, however, was old, its oscillation short, and its banks high and consolidated. But, even if it could have been opened, its natural outlet to the eastward, the Coomar, was older still, and less likely to give way; from a two- or three-mile oscillation, which can still easily be traced, it had sunk to one averaging half a mile or less. No water runs through it in the dry weather, and during the inundation the flow is so sluggish that all the silt it receives is spread on its own banks; consequently it has raised its district higher than any of the surrounding country.

Proceeding up the stream, the next river was the Goraie. This was more tractable; it was not originally a distributary, but a local stream, draining some jheels—it was consequently only at its head that its banks were at all stiff or consolidated; lower down the land was low, and the river divided into several branches, each of which could be opened out separately. Even its upper reaches were so tractable, that, from a width of 600 feet, at which it stood in 1828, it has increased to 1908, which is now the least width at the lowest season. The next river upwards was the Upper Coomar. It has not been opened to the same extent for the reasons just stated; but, as the pressure the Ganges could bring to bear upon it was infinitely greater than could be effected by the Chandna on its lower division, it has been opened and increased from 330 to 792 feet, and both these rivers are still increasing.

When these three came together above Baboocally, there were several courses open to them; the most natural one—for the Coomar at least—would have been to have opened the Novo Gunga. Though called *new*, this, however, was the next oldest stream of the district, after the Coomar. Its oscillation is only half a mile, and its banks are consolidated and thickly inhabited; and though, no doubt, some of its reaches might have been lengthened, still if, at any one place, two or three oscillations are so stiff that they cannot be extended, they govern the whole; and as there are several such in this river, its increase was hopeless.

The Barassya looked more favourable, and a part of its bed was actually appropriated and widened; but there were two oscillations opposite Muddenderry Factory which were in such stiff soil that they could not be extended, and, though the river has been somewhat widened and deepened, it remains now practically the same as when Rennell surveyed it.

To any one unacquainted with the habits of rivers, it will imme-

diately suggest itself that the easiest escape from these difficulties would have been to break into that long low range of jheels behind Mahmudpore, and so get to the sea without difficulty. As I have, however, tried to explain above, water resists water better than land. It broke several times into the low land, but was on every occasion repelled, being forced to deposit its silt so as to make a barrier against its own incursions.

The only remaining course, and the one that eventually was adopted, was to seize on a small khal, or creek, called the Ellan Khalee, and widen it for the purpose. This was not difficult, as the land was low and friable, no great river having come that way in recent times.

In Rennell's time the creek was so insignificant that it is not mentioned in his maps, and even in 1818–20 it was so small that it could be easily leaped on horseback; when I first knew it in 1830–33 it was sweeping through the country with two-mile oscillations, as regular as if they had been drawn by hand. It was nearly 800 yards wide, and deeper in proportion than the older rivers. It was, in fact, the only river that all the year round was open for steam-navigation between Calcutta and the upper provinces. After being rejoined by the Novo Gunga and Barassya, it increases its reaches to three miles, and carries this oscillation to the sea—certainly the largest and finest of the delta-rivers after the great Poddah* or Megna.

Since I surveyed it in 1833 it has been getting straitened in its bed, and it evidently has been embanking itself too rapidly. Its reaches have lost their beautiful regularity and have become contorted; and one of them has stretched about two miles to the eastward, so as to cut off the Muddenderry reaches. If it has accomplished this—which I believe it has—it may be able to open out the lower part of the Barassya River, and get into the low country behind; and then, perhaps, joining some of the old branches of the Ganges which existed in Rennell's time, so get to the sea.

If this should be accomplished, the Goraie and the Upper Coomar, with the Chandna, will practically become the great outlets of the Ganges, and the whole of the eastern half of the delta will then be abandoned to the Brahmapootra. This will certainly be the case if the Ganges' waters find a sufficient outlet in this direction; and the chances are so equally balanced that the struggle is extremely interesting at the present time.

7. *Natore Group of Rivers.*—The Ganges at Jaffiergunge, united with the Natore rivers at Oorasagur, is so nearly a match for the Brahmapootra, that the latter river is attempting to escape the conflict by cutting off the angle at Attree, and joining the Dallaserrai through the Elamjanee River. To do this effectually, however, it must open

* Poddah, or Padma (the Lotus), is the stream, running nearly east and west, by which the Bhagaruttee, or true Ganges, above Bauleah at some recent time connected itself with the Brahmapootra somewhere above Jaffiergunge. The tradition of this junction taking place is quite distinct in the minds of the natives inhabiting its banks, who do not consequently look on the Poddah as a sacred stream. Still it must have taken place before the diversion of the Assam river into Sylhet.

out some eighty miles of tolerably settled watercourses; and this would occupy some twenty years, even if it succeeded eventually. Our knowledge of the country is still too imperfect to enable us to predict the result with certainty. Whether it can accomplish this or not depends more on the success of the Goraie and the Jessore rivers in finding an outlet for the waters of the Ganges, than on the resistance of the eastern country. I may, however, be allowed to remark, in passing, that it will be a great advantage to the delta if the Brahmapootra does maintain its present course, and continues to act as a *barrage* to the waters of the Ganges. There is a great deal of land to the westward that would be improved by being raised, while it would be an immense benefit to the internal navigation if the Kishnaghur rivers could again be opened, and these objects can only be attained by the persistence of the eastern rivers in their endeavour to confine the western to their own territory.

If the Brahmapootra is able to maintain its present position at Jaffiergunge, another effect will be, that by continually damming back the waters of the Oorasagur, it will force the Natore rivers to deposit their silt, and to fill up the very low country through which they run. A good deal has already been done in this direction since Rennell's survey; and if the action continues much longer, they must abandon the struggle with the Brahmapootra, and seek an outlet somewhere between Bauleah and Surdah, some eighty miles further up the stream of the Ganges.

It follows from all this that, if the Brahmapootra continues in its present bed, it will almost certainly close the eastern outlet of the Ganges. At present it is kept open by a rather curious process, which it may be worth while to describe.

As before mentioned, the principal means by which the Megna defeated the Brahmapootra was by being first in the battle-field; and though the Brahmapootra is slower than the Megna, it is quicker than the Ganges, owing to the length of course of the latter river, and its depending more on the melting of snow than on rain.

The consequence of this is that, for the first month of the inundation, the water in the Ganges above Jaffiergunge almost flows backwards, and the Echamuttee at Pubna flows into the Ganges instead of out of it; and, during this season, the deposit in its bed is very considerable. But, during the last month of the rains, when the waters of the Brahmapootra have nearly run off, the immense body of water spread over the vast plains of Hindostan rushes into the partially deserted bed of the Brahmapootra, which then acts as a waste-water reservoir, and with a force that, to a great extent, clears out the deposit of the earlier months, and so restores the equilibrium.

This has been so entirely the case of late years that the Ganges has straightened its course very considerably below the head of the Jellinghy. The first result of this was to cut off a great six-mile bend on the left bank just above Pubna. This took place some thirty years ago. Within the last two years it has cut off the next bend on the right bank, leaving the Koostee Station of the Eastern Bengal Railway some two or three miles below the head of the

Goraie, instead of two miles above it on the Ganges as it originally was, and was designed to be; and if this sudden rapid rush at the end of the rains can be maintained, it probably will suffice to keep the river open, and so maintain the present *status*.

It will be easy to perceive how this effect takes place, if we bear in mind that the fall of the country between Pubna and Jaffiergunge (thirty-six miles) is only about seven feet; and if all the waters were supplied by one river, that would be their slope; but if, at any moment, the waters of the Brahmapootra should be seven feet lower than those of the Ganges, the slope will be doubled; and if ten feet, the scour must be tremendous; and it is believed that this was the difference when the last bend was cut off.

8. *Kishnaghur Group of Rivers.*—After the Jessore rivers just described, the only other great group of distributaries of the Ganges is that known as the Kishnaghur rivers, and consists of the Bhagaruttee, Jellinghy, and Matabangah, which, uniting above Sooksaghur, form the Hoogly.

Of these the oldest is the first-named. Indeed, if we consult either native traditions or internal evidence, it is the Ganges itself, and bears the same sacred name here as it does at its source; the name Ganges, which is applied to the intermediate portion, merely means Gunga or Gonga—the *river* "par excellence."

Whether we look at it from a geological or an historical point of view, there can be little doubt that the original river, after passing Rajmahal, would naturally run southward, parallel, or nearly so, to the course of the Brahmapootra at that time, the distance between the two being probably under ninety miles. The intermediate space would then have been fully occupied by the Coosy, Mahanuddee, Atree, Teesta, and other Himalayan torrents, all of which were probably at that time tributaries to the Brahmapootra; though, in consequence of the extension of the delta, they have most of them seceded to the Ganges.

It is probable that the Bhagaruttee River, or true Ganges, always flowed very nearly in the direction it now does, the extension of the delta on the left being about sufficient to counterbalance the repulsive action of the More, Adjie, Damooda, and Roopnarain, on its right bank. There is, indeed, no improbability in supposing that the original state of things may be, to a great extent, restored before long. All the silt of the two great rivers has been employed for a considerable time in raising the eastern half of the delta, and as that rises it throws the waters westward; and though we can hardly contemplate the Great Ganges flowing again past Moorshedabad, there is every reason to suppose that the body of water flowing through the Kishnaghur rivers will largely and steadily increase.

It is not very easy to ascertain now which were the earliest assistants of the Bhagaruttee in distributing the waters of the Ganges; but, of those which have left any traces, three may be mentioned as the best known. The first of these was the Coomar, mentioned before, and running E.S.E. nearly parallel to the bed occupied by the Ganges fifty years ago; the Boyrub, running south-east; and the

Echamuttee, taking an intermediate course between the last-named and the Hoogly, whose course is due north and south. As mentioned above, the lower part of the first-named river was cut off by the Chandna, and it then dried. The upper half long remained moribund, but was revived by the late invasion of the Brahmapootra. The second was extinguished, probably some 300 or 400 years ago, by the Jellinghy, which, when the slope of the delta towards the east became less, turned its waters from the south-east to south by west, and with them joined the Bhagaruttee at Nuddea, the Nyadwipa of olden times—a new island when the neighbourhood was a sea, or at least a tidal swamp. The third was nearly meeting a like fate from the Matabungah, which, appropriating a part of the bed of the Coomar, and then a part of the Echamuttee, opened out the Choornee nullah of Rennell, and joining the Hoogly above Sooksaghur, it promises, if not checked, to play an important part in the fluviatile history of the delta.

The cause of the recent increase of the Matabungah is, of course, the action of the Brahmapootra on the lower Ganges, and its inability to open up the Coomar suddenly, or the Echamuttee, which is an old and thoroughly settled river, with high consolidated banks and very short oscillations. Its success, however, will mainly depend on whether it can so open out the Hoogly as to admit of its taking off the extra supply of water it may bring down. Whatever the ultimate result may be, it began vigorously. At Sooksaghur there was a noble country-house, built by Warren Hastings, about a mile from the banks of the Hoogly. When I first knew it in 1830, half the avenue of noble trees, which led from the river to the house, was gone; when I last saw it, some eight years afterwards, the river was close at hand. Since then, house, stables, garden, and village are all gone, and the river was on the point of breaking through the narrow neck of high land that remained, and pouring itself into some weak-banked nullahs in the low lands beyond; and, if it had succeeded, the Hoogly would have deserted Calcutta. At this juncture the Eastern Bengal Railway Company intervened. They were carrying their works along the ridge, and they have, for the moment at least, stopped the oscillation in this direction. If they are able to do so in future, it will remain to be seen whether the Matabangah has the power to open out the reaches of the Hoogly so as to take off the water; but this I doubt. The river is old, its banks are high and much built upon, and great sums of money would be spent in groins and embankments to stop its encroachments. These may be successful; in which case it must open up the Echamuttee, or break through somewhere and get behind Calcutta. This might not be a serious misfortune for that city; indeed, the Hoogly becoming a mere tidal estuary like those of the Sunderbuns, without any silt-bearing streams flowing into it, would be an advantage, were it not that lower down there are two rivers, the Damooda and the Roopnarain, which would probably, during the rains, be able to shut it up if there was not a very heavy counterbalancing pressure from the Kishnaghur rivers to keep it open.

Not very long ago, if we may trust tradition, the Damooda joined the Hoogly at Satgong, above Hoogly; and even in Rennell's time the old bed was open, and is marked in his maps; but it was bent back, and was evidently, in his time, losing its gripe on that stream. It has now, like the Sylhet rivers, been bent south, and, like the Megna, lies in wait further down, prepared, in conjunction with the Roopnarain, to retaliate if any accident or moment of weakness should come over its old antagonist, the Hoogly.

According to the natives, this great change took place only in 1757–1762 *, when the Damooda burst into what had been the old channel of the Bhagaruttee and joined the Hoogly—the new name of the new stream—close to the mouth of the Roopnarain, which the natives persist in asserting is an old mouth of the Ganges; and they are probably right, though Major Rennell, in his Atlas, takes the trouble of denying it.

If the time when this great change is said to have taken place be even approximatively true, it affords a much more satisfactory explanation of any change that may have taken place in the navigability of the Hoogly than can be derived from any silting-up of the Kishnaghur rivers, which seem to have remained unaltered at least since Tavernier travelled in India in 1666, when these rivers seem to have been pretty much in the state they now are. But if the land is rising rapidly in the eastern half, especially about Jaffiergunge, which there seems no reason to doubt, while there has been no change of level in recent times in the western half, it follows, almost as a certainty, that the western rivers must go on gradually but steadily increasing in volume, and with them the quantity of water flowing through the Hoogly.

On the whole, therefore, it seems fortunate for Calcutta that the Hoogly did not break through at Sooksaghur; and this circumstance will be a benefit to a large portion of the delta if it forces either the Echamuttee or the Boyrub again to open its oscillations. As mentioned above, both these rivers were cut off by the Jellinghy and Matabangah when this part of the delta had been so raised that the inclination was rather to the west than the east or south. When the town of Jessore was built on the Boyrub, some 350 years ago, it is said that it was situated on the sea-shore, though this probably only means that the country to the southward of it was a tidal swamp, which, so far as we can judge, was the condition of a great portion of the delta at that period, though the seaward face of the Sunderbuns was probably the same as it now is.

It must have been immediately after this that the Kishnaghur rivers cut across the Boyrub, and deprived it of its supply of Ganges water; for at a distance of about six miles below the town of Jessore it ceases to be a "depositing" river. Up to that point its banks are high and firm, its oscillations quick, and it has all the appearance of an active river. For twenty-five miles from that point it runs to Culna, and beyond it, as straight as a canal, through an immense tract of jheel-land. It has had no silt to form banks, or

* Capt. Sherwell's Report on the Rivers of the Ganges, 1858.

to raise the country; for nearly forty miles in length and some twenty to thirty in breadth; while, as the more active rivers on either hand have raised theirs, this remains an immense half-inhabited tract, which is yearly getting relatively lower, and will become absolutely uninhabitable unless some active silt-bearing river turns in that direction. Whether it will be from the westward or the eastward that the succour will come remains to be seen. My impression is that it will be in the latter direction. Already the Ellankhally has sent the Chittra in a south-westerly direction across the Boyrub at Kulna; and it has done a great deal of good in raising the depressed country. This stream is not marked in Rennell's maps. When I knew it, it was narrow and crooked, but deep and navigable. It has now one-mile oscillations, with a width of about 1200 feet, and is increasing. Its only defect is, that it strikes the Jheel-country too low. What is wanted is that the Ellankhally should send off a branch a few miles below the junction of the Novo Gunga, which would enter the heart of the swamps. If it does not find an opening to the eastward, across the Barassya (which, as mentioned above, it is now seeking), it will probably turn in this direction, as it affords an opening which, though not so promising, is yet probably more easily accessible than the other.

9. *Changes in the Course of the R. Teesta.*—Before leaving the rivers of the Delta, there is one that exhibits phenomena of so different a class that it may be well worth while noticing them, in order fully to understand the subject.

The largest tributary to the delta-streams, east of the Coosy, is the Teesta. It rises in the Sikkim Mountains not far from Darjeeling; and when surveyed by Major Rennell, it took a course due south after passing Julpigoree, joined the Attree, and, after flowing past Dinajepoor, joined the Natore rivers, and thence, passing through the Oorasagur, joined the Ganges at Jaffiergunge. In the year 1787, either one or two years after Major Rennell's survey was completed, an unusual flood occurred; the river brought down from the hills a sufficient quantity of sticks and stones to throw a dam across its junction with the Attree, and, taking a south-east course, it joined the Brahmapootra above Dewangunge.

The curious part of the matter is that, on looking into Rennell's original MS. surveys, a chain of ponds is marked in this direction as "the old bed of the Teesta," too insignificant to be marked in his Atlas; but at their junction with the Brahmapootra he does mark "Teesta Creek." To those who know how permanent the names of rivers are, this is proof positive that the river once before flowed in this direction; but, unfortunately, we have no knowledge when it deserted this bed and became a confluent of the Attree. Since the separation, however, it has shown no tendency to go back, but runs steadily in the direction it took seventy-six years ago, and in which it now flows with an oscillation of two miles, and a width, even in the dry weather, of some 2000 feet.

One thing, however, may be remarked, namely, that it certainly was not any change in the level or the course of the Brahmapootra

which induced the change. Julpigoree, where the alteration took place, is 200 feet above the level of the river at its mouth, and it flows for the first forty or fifty miles with a fall of 3 feet per mile; for a like distance further on the fall is 2 feet, and the slope gradually sinks to 6 inches, or it may be less; but nowhere is it a depositing river or, consequently, influenced by back-waters; and it therefore appears to have been merely an accident which caused the change, though being so, it is as likely to go back any day as to remain in its present position.

10. *Retrocession of the Junctions of tributary Streams with main Rivers.*—There still remains one class of phenomena to which I must direct attention before concluding, namely, the shifting upwards of all the mouths of the tributaries of the Ganges along the main stream. This is, perhaps, the most generally interesting of the alterations that are taking place, not only from the magnitude of the changes it superinduces, but because of its forming the best chronometric scale for estimating the extension of the delta and the recent sequence of events.

Although I am not aware that they have been anywhere alluded to before, the causes that lead to the changes appear to be tolerably obvious when pointed out.

In order, however, to make myself perfectly understood, let me first refer to what I said about secular elevation in an early part of this paper, and then assume two hypothetical cases, which I trust will make the matter quite clear.

First let me assume hypothetically that the Ganges, from Allahabad to Rajmahal, was a perfectly horizontal canal or arm of the sea, running due east and west. It is evident that the slope formed by the rivers bringing down detritus from the hills on the north and south would dip north and south—but their plains would equally be horizontal in a direction east and west—and consequently that all the

Figs. 3–6.—*Diagrams illustrating the Junctions of tributary Streams with Main Rivers.*

Fig. 3.

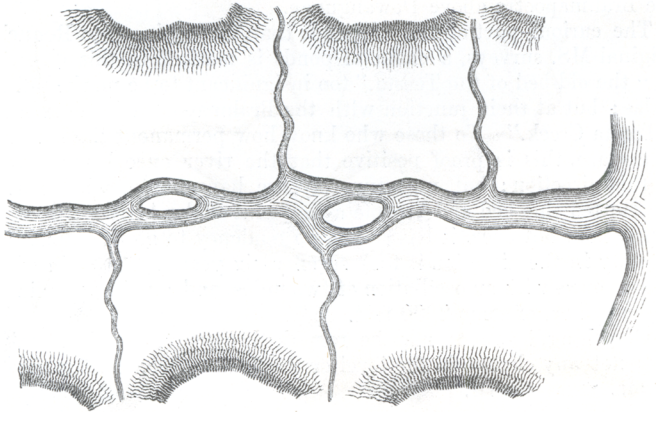


Fig. 4.

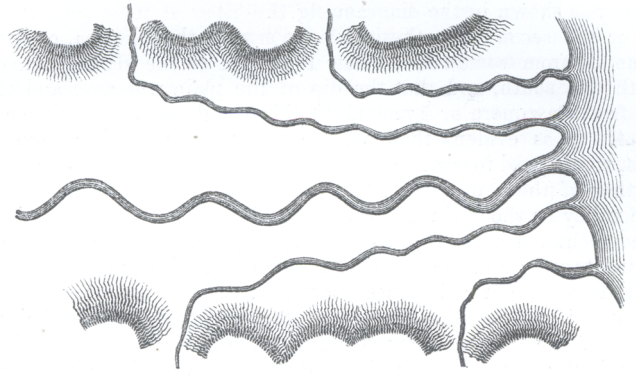


Fig. 5.

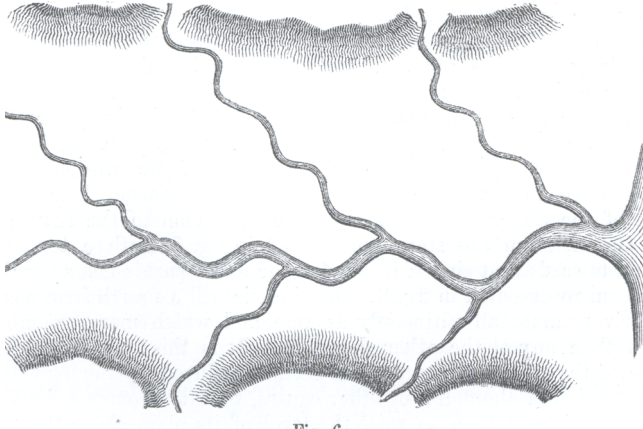
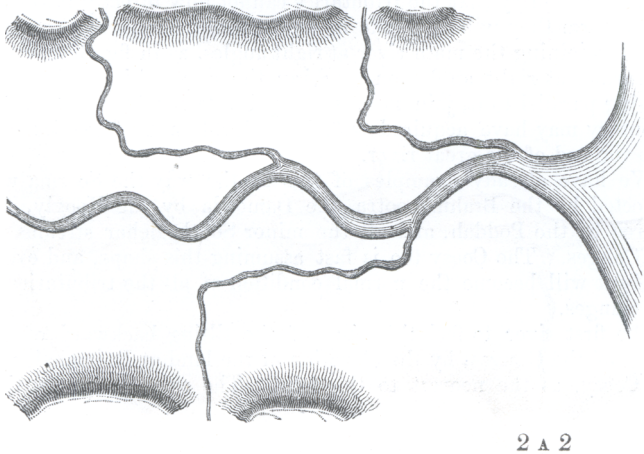


Fig. 6.



tributary streams would join the assumed Ganges-canal at right angles, as shown in the diagram, fig. 3.

For the second hypothesis, let me assume that the sea, or canal, extended from somewhere below Rajmahal to the Himalayas, due north and south, and that the dip of the plain was west and east, say from Cawnpore or Fyzabad to this canal or sea, as shown in fig. 4. It is evident that all the streams, on issuing from the hills, would tend to turn eastward, and to run parallel to the Ganges. Neither of these, of course, truly represents the facts of the case. The valley or the basin of the Ganges, like that of almost all rivers, is compounded of these two plains, varying in slope according to circumstances; and the course of the tributaries is along the diagonal or mean of these two intersecting plains.

Thus, if we assume that when the sea was at Rajmahal the slopes of the two plains were about equal, as shown in fig. 5, all the tributaries would join the main stream at about an angle of 45°; but the extension of the delta has now raised the land about this place to nearly 80 feet above the sea-level. This has been equal to tilting back the valley of the Ganges to that extent, without materially affecting the slopes of the lateral plains, as they are shorter, and start from much higher fixed points at the foot of these hills. The consequence is, that the angle of 45° is always tending to increase, and must eventually reach 90°, or nearly so, in all cases.

There are only slight indications in Bengal of the state of affairs represented in fig. 4, but it can be traced in parts. The upper part of the valley of the Ganges, from Allahabad to the mouth of the Gogra, is in the state represented in fig. 5, with a tendency rather towards that shown in fig. 4. The lower part is fast assuming the form represented in fig. 3. But there is still a fourth form which the rivers must all ultimately assume, and which more resembles fig. 4 than any of the other diagrams. It is this: as soon as the slope of the principal stream has been so reduced by the elevation or extension of the delta, or other causes, that it becomes a depositing river, it will then so raise the level of its plain above the surrounding country that the tributaries cannot flow directly into it.

The form they will then take is shown in fig. 6: having been reduced to joining the main river at right angles, as in fig. 3, they will be turned at right angles on reaching the edge of its plain, and, flowing parallel to it, join it at some point lower down, where the tributary may have acquired sufficient elevation to force its way into the bed of the great river.

We have already examples of this in the way the Soorma was deflected by the Brahmapootra, the Damooda by the Hoogly, the Attree by the Poddah, and all the minor South Behar streams by the Ganges. The Coosy too is fast assuming this shape, and eventually it will become the normal condition of all the tributaries of the Ganges.

The first river to feel the effect of the tilting backward of the plane of the Ganges, by the elevation of the land at Rajmahal, was the Coosy, as the nearest to the delta. The consequence is, that

when Rennell surveyed Purneah, he saw, and recorded in his memoir in the 'Philosophical Transactions' *, as well as in his Atlas, that the Coosy had at no distant date flowed past the station at Purneah, and joined the Ganges forty-five miles further down than its present junction. Buchanan Hamilton not only confirms this, but adds:—"This tradition is not only supported by the above-mentioned appearance, but by the opinion of the Pundits, or natives of learning, who inhabit its banks. These, indeed, go still further, and allege that in times of remote antiquity the Coosy passed south-east by where Tajpore now is situated, and thence towards the east till it joined the Brahmapootra, having no connexion with the Ganges;" and he adds, "this opinion seems highly probable" †. Indeed, an attentive study of the successive changes that have taken place renders this almost certain; and it is probable that the Oorasagur is the mouth by which the combined waters of the Coosy, the Mahanuddee, and the Attree were originally discharged into the Assam river.

Were it possible, it would be extremely interesting to know when this was the case. We may certainly assert that it was before the Madoopore jungle was upheaved—and when, consequently, the course of the Brahmapootra was very nearly what it now is—and also at a time when the tide, or at least very low land, extended to Pubna or thereabouts; and that this should have occurred within the very limited range of the traditions of Lower Bengal induces me to suppose that the beginning of the Christian era is the highest antiquity that can be ascribed to such a state of things. It may be much later.

The present course of the Coosy is so nearly perpendicular to that of the Ganges, that its direct junction can hardly travel more than a mile or two further up stream. The first result of any further rise in the level of the Ganges will be that of decreasing the radii of its curves, making it more winding, and converting it into a depositing stream, which it hardly is at present

The rising of the deltaic plain has already produced another effect since Rennell's survey was made, the middle, or the belly, of the river having travelled westward some four or five miles throughout the greater part of its course; and it shows a great tendency to go further in this direction—in fact, to emulate the example of its old confluent, the Mahanuddee, which forms a curve extending thirty-five miles to the westward of the straight line in which we may reasonably suppose it reached the Ganges at no very distant date.

As just mentioned, its junction with the Ganges tends to assume the rectangular form explained in fig. 6; and though its main course is steadily travelling westward, its mouth may travel eastward; and, before many years are over, it probably will again join the Ganges as low down as it did when its main stream flowed past the station of Purneah.

The principal river of the Tirhoot district is the Bogmutty, which presents exactly the same phenomena as those last described. It has an old bed to the eastward, much more perpendicular to the

* Vol. lxxi. p. 87. † Martin, vol. iii. p. 15.

course of the Ganges than that it now occupies. It has now been deflected so far westward that it joins the old bed of the Gunduck, and, in our careless nomenclature, actually gives its name to the lower part of that stream, and in Rennell's maps is so called at its junction with the Ganges opposite Monghyr.

The next river to feel the effect of these changes was the Gunduck. In this instance the evidence is as clear as could be desired. A river marked on our maps as the Little Gunduck—sometimes, but very improperly, as just mentioned, called the Bogmutty, from the name of its principal tributary—joins the Ganges opposite Monghyr; and there can be little or no doubt that it was what it is styled in the maps of the recent Survey, the *Boor* Gunduck, or old bed of that river.

Judging from the height of its banks and that of the land in its neighbourhood, and the extreme sinuosity of its course, this old river must long ago have ceased to flow with any vigour. A date might possibly be found for the time when this was the principal river; but, with the information at present available, all we can say is that it was so at a time when the country was sufficiently inhabited for the nomenclature of the rivers to be fixed.

At the earliest period to which anything like authentic history reaches, this river seems to have been distant from its present channel about twenty-two miles to the north of its present mouth, near Bakhra, or the site of the famous city of Vaisali, celebrated as the place where the second convocation of the Buddhists was held, 300 years before Christ, and to have joined the Ganges some thirty-three miles further down than at present. It is now so nearly perpendicular, that it will probably be a long time before it travels much farther westward.

Proceeding upwards, the next river of any importance we meet is the Soane. Here, fortunately, we have more precise information. Arrian, Strabo, and Pliny—or rather Megasthenes—tell us that Palibothra, the great capital of this country, was situated at the junction of the Erranaboas and the Ganges. Recent antiquarian discoveries have left no doubt that Patna—"Palibothra"—is the city designated, and that the Hyranya Bahu—the Golden-armed, or, popularly, the Sona, or Golden—is the river; and, fortunately, an old branch of the Soane can still be traced, from a spot about twelve miles up the stream to near the west end of the present city. In Rennell's time the Soane joined the Ganges at Moneah, twenty-two miles further west, by a single mouth. Since his survey it has formed a delta, and the upper mouth is the more important; so that, practically, it may be said to have receded four miles since that time. If in eighty years it has progressed so much, in 2000 it ought to have gone back 110 miles, instead of only twenty-five or twenty-six; the probability consequently is, that the delta was not then sufficiently extended or raised to affect rivers so far up the stream; indeed, it may have been 1000 or more years after the fact was notified to us that the elevation of the delta was first felt so high up as Patna; and, if so, we

may expect that the retrocession will now go on at a rapidly increasing rate. Whether our railway-works and bridge may be able to prevent this or not remains to be seen. If they do so, it can only be at an enormous annual expenditure for embanking and repairs. In fact, had the engineers been aware of this physical fact, they would probably have placed their bridge very much further up the stream than they have done. But be this as it may, it will be extremely interesting to watch now the progress of the stream; and having two surveys, separated by an interval of eighty years, and the old indications of the Greek geographers, we may from these data obtain a tolerable index by which to measure the progress of the delta seawards, or its progressive elevation above the sea-level at Rajmahal.

The next stream that ought to be affected is the Sarjoo, or Gogra. It does not, however, seem to have been affected at all; indeed, at first sight, it seems to have been moved downwards since Rennell's survey. This arises, however, only from the Ganges having cut off a sharp bend at this point of its course, and the river Gogra flowing through the arm thus left unoccupied. It does not appear probable, however, that it can remain much longer uninfluenced by these changes; but, until it is so, it may be taken as the fixed point beyond which the extension of the delta has not in recent times affected the slope of the bed of the Ganges.

The only indication I have been able to obtain of the Gogra, or Ghagra, having travelled westward, in historical times, is the following:—

There is an old bed of an old river which leaves the present Gunduck at a point somewhere between Bakhra and Lalgunge, and joins the Ganges opposite Bar. This branch, I have just stated, was probably an old bed of the Gunduck; but it still bears the name of Ghagra; and those who know how permanent Indian names are will hardly hesitate to believe that it may have been an old channel of that river. The evidence cannot be considered as conclusive, however, as I have been unable to trace the course of that river across Sarun. Nothing can be more probable than that, when the Gunduck joined the Ganges opposite Monghyr, the Ghagra should have joined opposite Bar; or that the Gunduck should have cut across that stream at Bakhra and occupied its lower portion, just as the Bogmutty has cut into the old Gunduck and occupied its lower portion; and, lastly, that the new Gunduck should have broken through and sought an independent opening into the parent stream. The Bogmutty will certainly do this one day; at present it is too small and weak a stream to act with the energy of the Coosy or Gunduck, but it must eventually come to this.

The next move must be that the Ghagra will seek a junction with the Tonse, and join the Ganges either through its bed or further west. I am not aware, however, that any tendency in that direction has yet been observed.

§ III. *Historical Evidence of Changes in the Delta of the Ganges.*

Having now run through all the principal phenomena to which I wished to call attention, describing them from a topographical point of view, allow me to recapitulate, as briefly as I can, the historical events connected with them, in order that their approximate dates may be judged of; for as all the events to which I have alluded appear to me to have occurred within historical times, and after the rivers had received their names from the Aryan races inhabiting their banks, we may, without difficulty, connect history with topography in this instance at least.

With the first dawn of history or tradition, about 3000 years B.C., we find the immigrating Aryan Hindoos traversing the Punjaub, and settling, so far as India is concerned, exclusively in the tract of country between the Sutledge and the Jumna. Their rivers were the Sareswati, the Caggar, and the Markandya, which must then have been far more important streams than they are now. Whether their decay arose from neglect of cultivation, after breaking up the soil, or from their raising their beds so as to spill towards the Jumna, or from what other cause, is by no means clear. The last-specified, however, is the most probable. The bed of the Sareswati, at a distance of twenty-four miles from the Jumna, is thirty feet higher than that river. The Caggar, at a distance of fifty miles, is ten feet higher than the last; and the country gradually slopes upwards till it reaches a height of fifty feet, close to the Sutledge, whose waters at Loodiana are at the same level as those of the Jumna at Kurnal*.

This tract, though not quite a desert now, is nearly so. Its rivers are insignificant streams, and lose themselves in the desert; and Thaneswara and Samana, the old classical cities of Arya-Varuta, are now nearly deserted.

The next capitals of this race were Delhi, on the extreme northern spur of a range of hills on the right bank of the Jumna, and Muttra, about eighty miles further down, but still on the elevated right bank. The first cities really in the plain were Hastinapora, on the Ganges, about fifty miles from the hills, and Ayodya, on the Gogra, at about sixty miles from the Himalayas, the last occupying the same position with reference to the valley of the Ganges that Sudya does to Assam; and it seems to have been one of India's most important cities between 2000 and 1000 years B.C. About the last-named date it appears to have been superseded by Cannouge, on the Ganges, this time 120 miles from the hills, being the farthest advance into the plains before the Christian era. Allahabad and Benares next rose into importance.

In the fifth or sixth century before Christ, when we become tolerably familiar with the geography of India, from the events of Buddha's life, we find, in the south, Rajagriha on the hills, and Gya close by, the most important cities of the central portion of the

* These levels are taken from a survey by Lieut. (now Col.) Baker, Journ. Asiat. Soc. Bengal, vol. ix. p. 688.

Gangetic plain; these were superseded about three centuries later, or in Alexander's time, by Palibothra, or Patna, which was the most important city of India at the time of Alexander's conquests*. On the north of the valley we first find Janakpore, in the Terai, between the Bogmutty and the Coosy, figuring as the capital of Bengal at the time when Ayodya was practically the capital of India; then Sravasti, Kapilavasti, and Kucinagara, all nestling under the hills close to the Terai, and the remains of ruined cities of this epoch within its now pestiferous limits,—showing that from the greater steepness of the slope, or some such local cause, this was then the most habitable part of the valley of the lower Ganges.

It is not till six or ten centuries after our era that we find any more important cities eastward of Patna; but, about the last-named period, Gour, opposite Rajmahal, became the capital of Bengal, to be superseded by Dacca, founded in 1604, and Moorshedabad, which only rose into importance in 1704.

For a century after 1634, when our ships were permitted to enter the Ganges, Satgong or Hoogly was the port of Bengal, and continued to be so till superseded by Calcutta.

The ships of those earliest days were no doubt much smaller than those afterwards introduced; but no sea-going vessel could well now get so far up the river. And it may also be remarked that when Admiral Watson attacked Chandernagore in 1757, he took up to that city what were then called line-of-battle ships, vessels of 60 and 64 guns, which, whatever their tonnage may have been, would with difficulty reach Calcutta now without the aid of steam.

It would be tedious, as it would be out of place here, to attempt to explain the data on which these historical conclusions rest, and pedantic to assert that they are more than approximate inductions from imperfect data. But I may state, generally, that long local study has left the conviction strongly impressed on my mind, that 3000 years B.C. the only practically habitable part of the alluvial plains of the province of Bengal was the portion between the Sutledge and the Jumna; that even 1000 years later it was only here and there, on the banks of some minor streams, that the country was in a state to support a large population, and to possess considerable cities; that nearly up to the Christian era it was only on the southern hills, or at the foot of the Himalayas (what is now the Terai), that cities could be placed, because the central parts of the plain eastward of the Gogra were still unfit for human habitation; that it was not till 1000 years afterwards that the plain of the Ganges was sufficiently desiccated to admit of such a city as Gour rising to importance, so far from the hills; and not till the Mahometan conquest in the 14th century that the Delta, properly so called, became fit for extensive occupation.

So far as can be judged from the rapid rate at which changes have taken place, and the immense quantity of land which has been

* The circumstance of four of the largest rivers in India—the Gogra, the Gunduck, the Soane, and the Ganges—meeting at one spot has so raised the country in the neighbourhood of Patna, that it must early have been a habitable tract.

redeemed from jungle and swamps, during the last century, there seems nothing to contradict this theory of the very modern origin of the present configuration of the valley of the Ganges.

It is not, of course, meant to be asserted that the valley of the Ganges was filled up, geologically speaking, within that period, but only that it became fit for man's occupation within the limits of the historical period, as hundreds of square miles of the Delta have become since Rennell's survey was made.

The greater part of the valley of Assam still remains—what the plains of Bengal may be conceived to have been 2000 or 3000 years ago—uninhabitable swamps, with occasional spots where cities have existed or do now stand. But if the principles enunciated above are to be depended upon, the recent changes in the course of the Brahmapootra ought rapidly to affect the level of the land in that valley; and it cannot possibly require a thousand, or half that number of years, before the swamps opposite Goalparah and Goahuttee become as dry and as habitable as the plains of Purneah in Tirhoot.

§ IV. *Increase of the Delta seaward.*

1. *Silt held in suspension in Ganges' Water.*—It will have been observed that, in the previous part of this paper, I have said nothing about the quantity of silt contained in the water of the rivers I have been describing, nor attempted to calculate its influence either in extending the delta seaward, or in raising it upwards. I have refrained from alluding to this simply because I know of no data on which any reliance can be placed.

To base any calculation on this agent, the experiments ought to be continued for, at the very least, one whole year, on some one at least of the larger rivers. But this has not yet been done; and, even if it were done for the Ganges, it must be nearly useless unless we had the same knowledge as regards the Brahmapootra, which I believe to be an infinitely more important stream in this respect than the Ganges itself. And we ought also to know what is brought down by the Mahanuddee, and the group of Natore streams debouching through the Oorasagur.

The latter rivers run through so low a country that they probably deposit most of their silt *en route*; but the Mahanuddee and its tributaries are swift, and strongly embanked. The Sylhet rivers may probably be disregarded; they never possess much silt, and what little they have they deposit at home, so they contribute little or nothing to the delta. Supposing, however, all this were ascertained for every river just as it enters the delta, another very important question arises—How much is deposited on the plains of the delta, and how much carried to sea? During the cold weather, when the rivers are low, almost all their silt will be carried to sea; but then the quantity of water is small, and that little comparatively clear. At the height of the inundation, when the river is overflowing its banks, at least one-half is deposited inland. As the rivers fall, the greater part will again be carried away; but as the force of the

current slackens, there is a great tendency for rivers to deposit their mud in their own beds, and to heal the wounds that have been made in their banks; so that even during that period it is doubtful if more than half is carried off. For instance, careful simultaneous experiments were made, two years ago, as to the quantity of solid particles held in suspension in the waters of the Matabangah,—first, at leaving the Ganges, when it was found to be 1 in 294 parts, while nearly at its junction with the Hoogly the quantity was only 1 in 884, proving that two-thirds had been deposited *en route* in that short distance*.

Sometimes an acre or two of a bank will fall in in a single night, and, consequently, the stream will be unusually turbid for the next twenty-four hours; but, in such an abnormal instance, one-half at least probably never leaves the local stream, but is deposited again a few miles further down; and, in fact, every stream and every locality has its peculiar regimen in this respect, and until they are more carefully examined than they have hitherto been, it will be safer to look to such indications as history affords us, and to our charts. These last show that little or no change or extension seawards has taken place, during the last 100 years, between the Hoogly and the Horringotta, or about halfway across the seaward face of the delta. But the eastern half is in a state of rapid change, having remained behind, I believe, principally in consequence of the absorption of the Brahmapootra's silt by the Sylhet Jheels; but probably in little more than a century or two from this time the gap may be repaired, and the Sunderbuns bounded by a nearly straight line east and west.

As regards the elevation of the delta, by far the safest test is the progress of the junction of the tributary streams, such as the Soane and Gogra. If the former be carefully surveyed from time to time, and the retrocession of the tributaries carefully noted, we shall gather far more satisfactory evidence of the gradual elevation of the delta than can be obtained by dipping tumblers from the sides of 'Budgerows,' which operation has hitherto been supposed to be sufficient to gauge the growth of continents.

2. *Swatch of "No Ground."*—There is still one other phenomenon which it is necessary to allude to, in order to understand the present or prospective condition of the seaward face of the delta of Bengal. This is the existence of a great depression, or hole, in the middle of the Bay of Bengal, known in the charts as the "Swatch of No Ground." Its exact position is shown on the map accompanying this paper (Plate XII.), and its sides are so steep and well defined that it affords mariners the best possible sea-mark—the lead suddenly dropping, especially on its western face, from 5 and 10 to 200 and even 300 fathoms, with "no ground."

It seems quite impossible to ascribe this sinking to volcanic action, inasmuch as we know that no such violent convulsion has taken place in Lower Bengal, during the last 200 years, as could have caused such a chasm; and it is not conceivable that so large

* 'The Ganges and the Hoogly,' by F. Prestage. Calcutta, 1861.

and so sharply defined a depression could have existed in so muddy a sea for even a fraction of that time without being obliterated or smoothed over, unless there was some tidal or fluviatile action always at work tending to keep it open; nor does it appear difficult to explain where this action is.

If we turn to the authorized chart of the mouths of the Hoogly, we find the following description of the action of the tides in that side of the delta. "The tides in the channels have a rotary movement with the sun, first quarter-flood W.N.W., round by N. to the last quarter E.N.E., to first quarter-ebb E.S.E., round by S. to the last quarter W.S.W."

The same description applies to those on the other side, with the difference that the larger portion of the tidal wave comes from the eastward—following the course of the sun. The circle there is considerably larger, as shown in the two black circles on the map. The action is, in fact, strictly analogous to that of the phenomenon known as the "Bore," which exists, to a greater or less extent, in all funnel-shaped tidal estuaries. The flood-tide, coming up the contracting bay from the southward, is accelerated on the shelving shore on either hand, and reaching the face of the delta at its eastern and western extremities before it touches the centre, this rotary motion ensues. The consequence seems to be that the two circular tides, meeting somewhere in the centre of the bay, must do one of two things—either they must throw up a bar or spit between them, or they must scoop out a depression. The first would be the action of two rivers, the velocity of whose currents was diminished or stopped by contact with the ocean. The latter seems the probable action of two tides whose motion is continuous and uniform.

It is quite reasonable to assume that the action of these tides might not have sufficient force to scoop out such a canal as this, if they found the delta perfectly formed and uniform across the whole head of the bay; but, as the tides certainly existed before the delta had been formed by the deposit of the silt of the rivers, there is no reason for doubting that their daily action is quite sufficient to sweep out and keep clear any channel which may be necessary for the efflux of these waters; and such, I feel convinced, is the true explanation of the phenomenon. It must also be borne in mind that there is every reason to suppose that the action of these tides has been constant and uniform ever since the Bay of Bengal took its present shape, and, consequently, it is probable that there may have always existed a bar or spit on the neutral line between the oceanic and river forces, somewhere not far from where the Sunderbuns now are. If this were the case, the deltaic plains would then have been, as hinted above, a great lagoon or inland sea—a circumstance which would tend very considerably to accelerate the deposition of mud in them, and thus to account for the rapidity of some of the changes, which might otherwise seem strange.

As the case now stands, the western tidal wave has had sufficient strength to sweep out the Balasore Roads, and to keep open the estuary of the Hoogly, known as Saugur Roads. Thence turning eastward

towards the Swatch, it seems to have sufficient force to fix the seaward limit of the western Sunderbuns as certainly as the current that passes eastward has fixed the seaward boundary of the Delta of the Nile.

The eastern half of the delta is by no means so fixed in its regimen, principally, I am convinced, owing to the cause pointed out in a previous part of this paper—in consequence of the Brahmapootra being diverted into the Sylhet Jheels, in which its waters were filtered, and its consequently bringing no silt seaward. We learn, however, from Lloyd's survey, made in 1836, that great progress had been made in filling up the gap since the beginning of the century; and if we had a new survey now, we might prophesy approximately how long it would be before the eastern face of the delta would assume a form as fixed as the western half.

The true base of the delta to seaward is the neutral ground between the 5- and 20-fathom lines, which there is no reason to suppose has altered, or will alter, in any time of which we can take cognizance; for, the whole of the silt brought down by the ebb being swept away to the depths of the ocean through the Swatch, there is no reason to suppose that any sufficient portion of it is brought back by the flood to alter so marked a boundary in any appreciable degree.

Inland there is another neutral line parallel to this, in the tract of high land extending from Calcutta to Bakirgunge, and when the delta is complete it will reach Seetacond; this marks the boundary where the tidal forces are stopped by the river's action, and where, consequently, a certain deposit takes place. Behind this inland barrier there still exists an immense tract of jheel-country, in the districts of Jessore and Fureedpore; but, judging from the extraordinary changes which have taken place since Rennell's survey was made, there seems no reason to doubt that, in the course of another century, if the rivers are left alone, there will be very little jheel-country left in the western half of the delta; and the task of the Ganges will then be completed, with the exception of a little smoothing and filling here and there. But it will take several centuries before the Brahmapootra will have rendered its domains, especially in Assam and Sylhet, as habitable and as fertile as the whole of the valley of the Ganges is, even at the present day.

§ V. Appendix.

The following Table, though constructed on the best available data, can only be regarded as an approximation to the truth, no surveys having been undertaken with reference to the objects in view; and though certain levels may be absolutely correct, they do not give either the average height of the land or of the water, or they give that only at exceptional periods.

The first two are from Col. Cautley's survey for the Ganges-canal; the next three from that for the East Indian Railway, and may be depended upon except as regards the correct representa-

tion of the true level of the mean high water or of the land at the places mentioned. The remaining levels are from the survey for the Eastern Bengal Railway, and may be depended upon within fractional quantities, both as regards accuracy and levels of water.

The whole is based on the assumption that the highest level of the floods represents the highest level of the land, and that this datum at Calcutta is 27 feet above the Howrah Dock Sill.

	Height, in feet.	Distance, direct.	Slope per mile.
Hurdwar	974	miles.	inches.
Cawnpore	402	350	19·3
Allahabad	269	122	13·
Patna Moneah	161	200	6·5
Rajmahal	68	185	6·
Calcutta	0	168	4·8
Kooshtee	27	100	3·2
Serajgunge	30	54	·8
Dacca and Naraingunge	4	76	4·1

This last would make the level of high water and of the land at Goahuttee about 100 feet, at a distance of 350 feet from the sea, which accords very tolerably with that of 70 feet given by Schlagintweit for the low-water-level above mean sea-level.

April 22, 1863.

Nicholas Kendall, Esq., M.P., Member of the Royal Commission of Mines, Pelyn, Cornwall; Major F. J. Rickard, Inspector-General of Mines in the Argentine Republic, 21 A Hanover Square, W.; and Charles Easton Spooner, Esq., Bron-y-Garth, Port Madoc, North Wales, were elected Fellows.

M. A. Favre, Professor of Geology in the Academy of Geneva; Franz Ritter von Hauer, k.-k. Bergrath, and of the Imperial Geological Institute of Vienna; M. Hébert, Professor of Geology to the Faculty of Sciences at Paris; M. E. Beyrich, Professor of Geology in the University of Berlin; and Dr. F. Sandberger, Professor of Mineralogy at Carlsruhe, were elected Foreign Correspondents.

The following communications were read:—

1. *On the* Gneiss *and other* Azoic Rocks, *and on the superjacent* Palæozoic Formations, *of* Bavaria *and* Bohemia. By Sir Roderick I. Murchison, K.C.B., D.C.L., LL.D., F.R.S., F.G.S., &c.

Introduction.—In my last journey to Bohemia, I had no sooner reached Darmstadt than I was gratified to find that, in two of the most