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Government of Western Australia, by whom it has been well received, a project for penetrating from the West Coast by the valley of the Murchison River, due eastward, until he reaches the central line of telegraph which now connects Adelaide with Port Darwin. This will involve the exploration of about 1000 miles of "terra incognita;" and as it is thought probable that a large river, or rivers, may be found running eastward from the watershed of the Murchison, the Expedition may lead to results of vast importance to the colony. When we see, indeed, that a telegraphic wire, bringing us daily intelligence from Adelaide, is now laid continuously across the continent from south to north, along a line which was only first explored by Stuart in 1860, there would seem to be no reason for distrusting the power of the colonists to cross the continent in due time from west to east. At any rate, their enterprising spirit deserves our best encouragement, and we accordingly offer to Mr. Forrest our cordial wishes for his success.

I would further desire to draw the attention of the Society to the very important papers on forests as connected with Hydrology, by Dr. Brandis and Mons. Lemoine, as well as to two excellent Memoirs 'On the Place of Geography in Education,' and 'On the Scope of Scientific Geography,' by the Rev. Mr. Hale and Major-General Strachey, which were read before Section E, at the late meeting of the British Association at Brighton, and the value of which was at the time pointed out by our accomplished Vice-President, Mr. F. Galton, who presided over the Section, and than whom no one is better qualified to discuss questions relating either to Physical Geography or to Geographical education. The Fellows must remember that although these topics do not possess the same immediate interest for the public as descriptions of travel and personal adventure, they are of far more enduring importance, and, in fact, lie at the root of the science, for the cultivation of which this Society was instituted.

And now, Gentlemen, before concluding, I have only to announce to you that the Council, taking into account the especial interest which at present attaches to the geography of the interior of Africa, in connection with Livingstone's explorations, have resolved to print an English translation of Dr. Lacerda's Travels from Tété to Cazembé, which has been lately placed at their disposal by our indefatigable correspondent, Captain Burton, and to circulate it, with the addition of a translation of the Pombeiros' journey, and an abstract of that of Monteiro and Gamitto, as a supplementary volume of the 'Journal.'

The Session may now be declared opened, and I hope it may

be productive both of instruction and amusement to the Fellows. We are promised many papers of interest, one of the most important being a detailed account of the ascent of Kilimanjaro, by the Rev. Mr. New, of which an abstract, contained in a private letter, was communicated to you in the summer. Mr. New, I may add, who was temporarily connected with the Dawson expedition, and whom the Committee declared in their Report to have come out of the enquiry unscathed and without having in any way forfeited their confidence, is at present in England; but it is hoped that ere long his services may be utilized in renewed explorations in Eastern Africa, for which his knowledge, experience, and thorough acclimatization render him peculiarly fitted.

Mr. C. R. MARKHAM, the Secretary, next proceeded to read the following paper:—

Dr. Livingstone's Exploration of the Upper Congo. By DR. E. BEHM.*

PROOFS OF THE IDENTITY OF THE LUALABA WITH THE CONGO.

THE view expressed in the title of this paper, that the waters discovered and traced through a great extent of country by Dr. Livingstone during recent years, do not, as he believes, belong to the Nile, but to the Congo, is now almost universally held by professed geographers: it appears frequently in the numerous writings and discussions upon Livingstone's and Stanley's reports. At the meeting of the British Association at Brighton, especially, its importance was sought to be maintained (in opposition to an audience unlearned in the geographical questions involved, and carried away by the presence and fluency of Mr. Stanley), and although adequate reasons were not brought forward for its support, yet the impression foreshadowing its truth gained ground as a necessary conclusion from the received facts.

Uncertainty was caused by the insufficiency of the arguments brought into the field; these were based on measurements of elevation, which, from the manner in which they were made, could only claim a small amount of exactitude, and upon the quantity of water in the rivers under consideration. Both of these arguments sufficed to separate the Lualaba from the Nile, not, however, to carry it to the Congo. For this a third element was necessary, which, being comprehended in the changes of the yearly seasons, is happily free from the errors of instruments and mistakes of travellers. As surely as the sun stands over the southern hemisphere in our winter, and over the northern in our summer, bringing the rains and the swellings of the tropical rivers when it is in the zenith in regard to them, so surely can it be predicated, from a comparison of the rainy seasons and times of rising, that the Lualaba belongs to no river of the northern hemisphere; in the southern hemisphere Africa possesses only one river, the Congo, which could take up the vast water supply of the Lualaba. It will now be endeavoured to establish the points thus indicated:—

(1.) *Elevations.*—In his despatch of 1st November, 1871, to Earl Clarendon, Livingstone writes:—"Most of the intelligent natives and traders thought that all the rivers of the upper part of that valley (the Lualaba Valley) flowed into Tanganyika. But the barometer told me that to do so the waters must flow up hill. The great rivers and the great lakes" (belonging to the

* Translated by Mr. Keith Johnston, from the 'Geogr. Mittheilungen.'

Lualaba) "all make their waters converge into the deep trough of the valley, which is a full inch of the barometer lower than the Upper Tanganyika. . . . The mean of many barometric and boiling-point observations made Upper Tanganyika 2880 feet high. Respect for Speke's memory made me hazard the conjecture that he found it to be nearly the same, but, from the habit of writing the Annum Domini, a mere slip of the pen made him say 1844 feet; but I have more confidence in the barometers than in the boiling-points, and they make Tanganyika over 3000 feet, and the lower part of central Lualaba one inch lower, or about the altitude ascribed to Gondokoro."

The height of Gondokoro on the Kir or Bahr-el-Jebel, the main stream of the White Nile, coming from the Albert Lake, has been comparatively well ascertained by various measurements. According to Baker it is 1999 feet; Peney makes it 2060 feet; the height obtained by Dovyak (relatively to Khartoum, 1345 feet from the mean of the best measurements) is 2068 feet; and Dr. Hann's investigations show that its elevation may be confidently taken at the average of 2024 English feet, and the surface of the Mwutan (Albert Lake) lies at 2720, or (according to Buchan's recomputation of Baker's boiling-point thermometer observations) 2500 feet above the sea. Although we cannot yet set any great value upon the elevation determined by Dr. Livingstone, since the observations have not been subjected to any critical examination, yet the important difference of level between Tanganyika and the central Lualaba must be considered as established. The agreement of Livingstone's height for the Tanganyika with Findlay's correction of Speke's observation (2800) creates a decided confidence in his measurements. That the Lualaba cannot fall into the Tanganyika is then abundantly proved by these facts; Livingstone has also directly shown this to be the case by the route which he has traversed; his voyage especially round the northern half of the lake with Mr. Stanley, during November and December of 1871, shows that in this part of Tanganyika, where alone a connection with the Lualaba was conceivable, there is no great inflowing river. The largest, the Rusizi, coming from the northern mountains, was found to be not more than 30 yards wide and very shallow.*

That the Mwutan (Albert Lake) is higher than the Lualaba may be accepted, if not with such certainty, at least with greater probability; for the lake must lie several hundred feet above the level of Gondokoro, which point is reached by its outflowing river after a course through several degrees of latitude, and down very considerable cataracts. Besides this, it is known from the observations of Baker and Speke, as well as through the reports received by Livingstone; that the high mountains of the Walegga form a rampart on the west and south-west of the Mwutan, which must be cut through by the Lualaba if it should take its course to the lake, and through the lake to the Kir. The approach to all the western tributaries of the White Nile is also barred to the Lualaba by the Uelle, which Dr. Schweinfurth crossed in 1870 under 3° 37' N. lat. and 28° 10' E. of Greenwich, and showed to be a north-westerly flowing river, altogether south and outside of the basin of the Bahr-el-Ghazal.†

The reports of Von Heuglin, Poncet, and Schweinfurth agree in stating that the Uelle does not belong to the Nile system; Schweinfurth has made it at least very probable that the Sueh, which he crossed in 5° N. lat. and 28° 30' E., is the upper course of the Jur; the Uelle could therefore only be identical with the Bahr-el-Arab if it did flow to the Nile: but, besides the assurance of Dr. Schweinfurth that he has convinced himself of the opposite conclusion, there

* Stanley in 'New York Herald,' 15th July, 1872.

† 'Geogr. Mittheilungen,' 1871. Map 7.

is the strong fact that the Uelle, where Schweinfurth saw it in the middle of April, before the commencement of its rise, or at its lowest stage, carries a greater volume of water than the united streams of the Bahr-el-Ghazal, as will be seen by a comparison made further on. The point to which the Uelle flows, whether Schweinfurth's identification of it with the Shari is probable or not, is beside the question; this, however, may be noticed in passing, that, by reason of the time of its swelling, it can have no connection with the Congo, and that the somewhat earlier rise of the Shari is no ground for separating it from the Uelle, since the Shari may have other tributaries coming from further south.

Is it possible that the Uelle can be the continuation of the Lualaba? Dr. Schweinfurth's aneroid observations made during his Niam-Niam journey have unfortunately been for ever destroyed, along with his diaries, by fire, but his preliminary computation of these, made during the journey, gave for the Uelle an elevation of 2200, and later applied corrections 2300 English feet. Even admitting a possible error of several hundred feet, this observation is fatal to any continuation of the Lualaba into the Uelle, because the lowest point visited by Livingstone on the former river was separated from Schweinfurth's crossing-point of the Uelle by seven and a half degrees of latitude. Moreover in the neighbourhood of the place where Schweinfurth saw it, the Uelle is formed by two tributary or source branches, the Kibala and the Gadda, and the direction of both of these appeared to the traveller "decidedly to point for their origin, both to the Blue Mountains which Baker discovered in the north-west of the Albert Lake, and to those in the north of Tanganyika, which Speke recognised long ago as the most important water-parting of the continent."

The existing measurements of elevation place no hindrance in the way of a union of the Lualaba with other rivers of Equatorial Africa,—the Shari, Benue, Ogowai or Congo,—since the known portions of these rivers all lie considerably lower than the Lualaba of Livingstone. The Shari was crossed by Dr. Barth about 90 English miles above its mouth in Lake Chad, and although he gave no measurement of its elevation, yet it is evident, from the level character of the land, that its bed cannot at that point be much higher than the surface of the lake, the absolute height of which was found by Vogel to be 850, by Rohlf's 1100 English feet. The height of the Benue in Adamaua is given on Dr. Barth's map at about 800 English feet, but the aneroid observations made during Baikie's expedition,* giving only 268 feet for Odjogo, seem to show that the former estimate is too great. The Ogowai, at the confluence of its two main arms, is certainly not more than 300 feet above the sea, because one of its branches, the Ngunië, was found by Du Chaillu above the Samba Falls to have an absolute height of 347 English feet.

Unfortunately there are no measurements of elevation for the Congo, but it can hardly have any great elevation above the point where it breaks through the chain of coast mountains. Tuckey's expedition believed that the highest mountains near the Congo were probably not over 2000 English feet high;† the most important cataract has a fall of only 30 feet on a stretch of 900 feet of the river course, and through the whole extent of the passage of the mountains the river remains for the most part navigable.

(2) *Volume of the Rivers.*—If the hypsometrical data make a separation of the Lualaba and the Nile probable, this probability becomes a certainty on a comparison of the volume of water borne by the separate rivers. At the lowest

* Baikie, 'Narrative of an Exploring Voyage up the Rivers Kwora and Benue.' London, 1856, p. 540.

† Tuckey, 'Narrative of an Expedition to explore the River Zaire.' London, 1818, p. 351.

point of the Lualaba visited by Livingstone (the market of Nyangwe, in 4° s. lat., and between 25° and 27° E. Gr.), its stream in July—that is in the dry season—was at the rate of from $1\frac{1}{2}$ to 2 English miles an hour; the depth so great that men and women were drowned in it before the eyes of the traveller. The breadth of the river he gives at from 2000 to 6000 yards, or, in another letter, from 1 to 3 English miles; and to this he adds that the Lualaba could not be forded at any point, or at any season. Taking the minimum breadth of 2000 yards = 6000 English feet, the depth at 8 feet, and the current at $1\frac{1}{2}$ mile an hour (equal to 31 inches per second), the volume of water is 124,000 cubic feet in each second. Fortunately there exist measurements of the White Nile and its branches, taken during the season of lowest water, so that the figures are comparable with each other, and with those given for the Lualaba.

Peney found the Bahr-el-Jebel (the Kir, or river of Gondokoro) above Gondokoro, at the village of Tambur, 45 mètres broad, and, on an average, $5\frac{1}{2}$ mètres deep, flowing at a mean rate of 85 mètres in a minute. Baker estimated the breadth of the same river above the mouth of the Asua ($3^{\circ} 34'$ N. lat.) at about 400 yards in March; at Jebel Kuku its width is increased by islands, rocks, and slime-banks, to one English mile, and again, at one place, it is compressed to a breadth of only 120 yards. Speke gives no figures, but he calls the Bahr-el-Jebel above the mouth of the Asua a "noble stream." Petherick, on the 25th of April, or shortly before the rise of the rivers, measured the Bahr-el-Jebel above the mouth of the Bahr-el-Ghazal, and the Bahr-el-Abiad below the mouth of the latter; and from these measurements he was enabled to estimate the volume supplied by the Bahr-el-Ghazal.*

Placing these measurements beside those of Schweinfurth, made in the middle of April on the Uelle, we have the following comparison:—

	Breadth in English Feet.	Average Depth in English Feet.	Current per Second in Inches.	Cubic Feet of Water per Second in the Dry Season.
Lualaba at Nyangwe—Livingstone	6000	8	31	124,000
Bahr-el-Jebel above Gondokoro— Peney	148	17	56	11,700
Bahr-el-Jebel above mouth of Ghazal—Petherick	224	22	20	8,288
Bahr-el-Abiad below mouth of Ghazal—Petherick	481	14	20	11,330
Bahr-el-Ghazal—Petherick .. .. .	..	..	..	3,042
Uelle in $3^{\circ} 37'$ N. lat., and $28^{\circ} 10'$ E. long.—Schweinfurth	325	$12\frac{1}{2}$	15	5,100

According to Schweinfurth's estimate, the channel of the Uelle at its very fullest, could only carry 17,850 cubic feet per second; and the vast superiority in volume of the Lualaba to the White Nile remains, even on comparison with the much higher results of the following measurements made, also in April, by de Malzac:—

* 'Proceedings of the Royal Geographical Society,' viii., No. iv., p. 122 *et seqq.*

	Breadth in English Feet.	Average Depth in English Feet.	Current per Second in Inches.	Cubic Feet of Water per Second in the Dry Season.
Bahr-el-Jebel	450	19	$64\frac{1}{2}$	45,600
Zerafa	49	6	14	350
Bahr-el-Jebel and Zerafa together	..	..	..	45,950
Bahr-el-Ghazal	587	$5\frac{1}{2}$	24	6,500

The Lualaba, then, bears at least nineteen times as much water as the Bahr-el-Ghazal, with which Livingstone would identify it, and not less than three times as much as the White Nile.

From these figures it is sufficiently clear that it is impossible for the Lualaba to be a tributary of the Nile. The accounts of the volume of the Shari and Benue are less satisfactory, and do not admit of any such decided contrast with that of the Lualaba.

The smaller western arm of the Shari, the river of Logone, was found by Barth at Karnak Logone in March to be, for the most part, shallow, in some places $8\frac{1}{2}$ feet deep, with a stream of about 3 English miles per hour; the breadth was from 550 to 600 paces. In the middle of August it became much larger, and, though not so broad as the Shari, yet it had a strong current of from $3\frac{1}{2}$ to 4 English miles an hour. The Shari itself, before its union with the river of Logone, was found to have a breadth of 2000 feet at Assu in March, and at Mele 1800 feet, with a channel 15 feet deep, and likewise a strong current. At the time of highest water the river sometimes overflowed its banks at the latter place, though these are more than 40 feet above its ordinary bed. Higher up, at Bugoman, the breadth was only from 1200 to 1500 feet, and the river had such a comparatively insignificant appearance that Barth at first took it to be a tributary: at this place also it appears to be, for the most part, shallow. In the middle of August the river at Assu showed a water-surface of at least 3000 feet broad; but this was broken up by numerous islands. The current was not greater than 3 English miles per hour, but the depth was so considerable that horses were forced to swim in crossing. In the month of September, when the waters are at their highest, the crossing is not attempted by the natives. The observations at Mele then give for the time of lowest water:—

	Breadth in English Feet.	Average Depth in English Feet.	Current per Second in Inches.	Cubic Feet of Water per Second.
Shari at Mele—Barth	1800	$7\frac{1}{2}$	60	67,500

Barth found that the Benue River, at the confluence of the Faro in Adama, was at least 1200 paces broad in the middle of June, and on an average 11 feet deep. The current proved itself so strong that Barth, in bathing, could not stand up against it (perhaps 3 miles an hour). The river had at that time fairly begun to rise; but, some months later, it was said to cover a point of land rising about 15 feet above its level, which separates it from the Faro. Judging from the evident marks on its banks, the Benue must often rise at least 50 feet. From these data a volume of about 198,000 cubic feet per second was calculated for the Benue, but, since the river was already consider-

ably swollen by the rains, a comparison of its volume with the previously noted rivers at their lowest stage, is not admissible.

Barth concludes, from the great and rapid rise of the Benue during the rainy season, that it must have its sources in mountains situated at no great distance inland, and the difference of its volume during the dry and wet seasons is so extraordinarily great that the river can hardly be supposed to flow from a great lake. Baikie is quite of this opinion when he says, "The Bînuwé with more rapid course has more of the characters of a gigantic mountain-stream; originating in rocky mountain-ranges, it depends for its supply on the heavy falls of rain in elevated regions When the cessation of the rains dries up its sources, this river merely flows tranquilly along its sandy bed." Edward Vogel, who crossed it in April, 1855, reports that at that time the water was only 4 to 6 feet deep, and without any current.† The Faro, when Barth visited it, was 900 paces broad at its mouth, and not above 2 feet deep.

The doubts which these imperfect and indecisive data admit of, in respect to a possible connection between these rivers and the Lualaba, are of little import to the present investigation, since the impossibility of such a union is evident in comparing the time of periodical swelling in these rivers. On the other hand, our very imperfect knowledge of the volume of the Ogowai would be a cause of regret, since, at the time of its swelling, it approaches nearly to that of the Lualaba, if the description given by the travellers upon it did not assure us of this at least, that neither of the tributary branches of the Ogowai can bear any comparison with such a mighty stream as the Lualaba.

The united Ogowai is indeed, a noble river. Serval's survey of it proves it to have an average breadth of 8200 English feet, and a strong current, with a depth at the lowest stage averaging between 16 and 48 English feet; though, in some places, its depth decreases to 6 or 9 feet, at others increases to 65, and even 80 feet. The "Nazareth" branch of the delta pours out such a flood of water that, even in the dry season, the water at its mouth is fresh during the flood-tide.

The great breadth is, indeed, reduced by islands and sandbanks, and the depths given refer only to the main channel, which at times is narrow, and difficult to find. The *Pionnier* river-steamer, in which the various French Ogowai Expeditions have been undertaken, could only reach a distance of 90 English miles up stream in the dry season of 1862, on account of the shallowness of the water; and, when at the confluence of the main branches in 1867, was compelled to go about quickly on the beginning of the decrease of the waters, in order not to be stranded on the return-voyage.

The southern branch, the Ngunië, was found to have a breadth in Apono Land (2° s. lat.) comparable with that of the Thames at London-bridge, 700 feet, and was in June from 10 to 15 feet deep; in the rainy season about 10 feet deeper. Of more importance is the northern branch, the Okanda, and this one alone can be admitted into the discussion. Walker found this river, above the confluence, at the point where it changes in southerly direction for a westerly one, to be from 600 to 700 yards (1800 to 2100 Eng. feet) wide, though bare sandbanks occupied about one-half of its bed. Higher up its course where rapids interfered with Walker's boat voyage, the river-bed is filled with rocks, and though the current is considerable, the breadth decreases to 600 feet. No reliable calculation of the volume of its water can be made from such data, but this much is certain, that the Lualaba, an impassable river of from 6000 to 18,000 feet in breadth, cannot find room for itself, either in the channel of the Ngunië or of the Okanda.

* 'Reports of Dr. Baikie on the Geographical Position of the Countries in the Neighbourhood of the Niger,' &c., p. 7.

† 'Zeitschrift für Allgem. Erdkunde,' vi., 1856, p. 486.

On the other hand the known Congo corresponds perfectly to the volume which the Lualaba must assume after its reception of the Quango and other tributaries. The Congo, as described in A. G. Findlay's Sailing Directions for the southern Atlantic Ocean (London 1855), "brings down an immense volume of water, which has hollowed for itself a narrow bed of very variable depth. In many places there is no bottom at 200 fathoms. Forty miles from its mouth its waters are only partially mingled with those of the sea, and sometimes nine miles out they are still quite fresh. . . . The main body of the stream of this mighty river is indicated by floating masses of bamboo, and débris of all kinds, which it carries far out to sea. The velocity of the current is said to range at from 4 to 8 miles an hour. . . . The stream of the River Congo is felt at a great distance out at sea, and ships which cross it in going to the North or to the South, ought therefore to guard against it. It is stated that 300 miles out the water is discoloured, and that the current of the river is perceptible at that distance."

Tuckey who has followed the Congo further than any one, found it, above the cataracts which it forms in breaking through the coast range, to have a width of from 2 to 4 English miles with an unbroken surface, and a current of from 2 to 3 miles an hour; and the statement made in his travels (p. xiv.) that at the lowest stage of its water, it discharges two millions of cubic feet per second, is confirmed by the more recent survey by Vidal. According to this survey* the river above Embomma (65 English miles from the mouth) has a regular channel, maintaining a uniform breadth for a long distance, only interrupted by a few very small islands.

Here, quite above the estuary, Tuckey found a current in the neighbourhood of the Diamond Rock, of 3½ English miles an hour, where Vidal's chart shows a width of 1½ nautical mile (9000 English feet), and a depth in the middle of the stream of 50 fathoms (300 feet).

Taking as a minimum only 10 fathoms of depth for the average, though that depth is shown quite close to the bank, and instead of 3½ only 2 nautical miles an hour for the current, we have for the

	Breadth in English Feet.	Average Depth in English Feet.	Current per Second in Inches.	Cubic Feet of Water per Second.
Congo	9000	60	40	1,800,000

The Congo is one of the giant streams of the globe; it surpasses the Mississippi very considerably, since by the exact measurements and calculations of Humphreys and Abbot† the Mississippi at Carrollton in Louisiana, in its channel of an average breadth of 2470 English feet, has 675,000 cubic feet per second as its mean volume for the year. This amount increases in March to 1,150,000, but sinks at the lowest stage of the water in November to 228,000 cubic feet; whilst the difference between highest and lowest water in the Congo is only from 8 to 9 feet, a proof that it is fed from great lakes. The Mississippi collects its water from a basin of 1,244,000 English square miles, but for the Congo there are at most only 800,000 square miles of drainage area available. If the basin of the Lualaba, to which, according to Livingstone's and Magyar's reports, the Kassabi or Loke (the Loeki or Lomame of Living-

* English Admiralty Chart, No. 625. Africa West Coast, River Congo, corrected to 1867.

† 'Report on the Physics and Hydraulics of the Mississippi River.' Philadelphia, 1861.

stone) is tributary, be deducted from this area, there would remain not more than 400,000 English square miles, an area which would not even suffice to form the Congo at its lowest state, since the rainfall of equatorial Africa (Manyuema Land) from Livingstone's observations during the rainy season of 1869-70, is not more than 58 inches; that is, not quite double as much as the average rainfall of the Mississippi region (30 inches).

Since then the Congo is the only river of Africa which in point of volume is capable of receiving the Lualaba, so, inversely, that inland river is necessary to account for the enormous volume of water which the Congo contains.

(3.) *Rainy seasons and the rise of the rivers.*

"The rainy season of a place within the tropics always begins when the sun has reached the zenith of that point. Then the trade winds, blowing regularly at other seasons, become gradually weaker, and at length cease and give way to variable winds and calms. The trade wind now no longer brings its regular supply of cooler, drier air; the rising heats and the calms favour an ascending current which bears the damp air into the upper regions of the atmosphere, there to be cooled down and to occasion the heavy downpours of each afternoon. The nights and mornings are for the most part bright and clear. When the sun moves away from the zenith, the trade winds again begin to be felt and bring with them the dry season of the year, during which hardly ever a cloud disturbs the serenity of the skies.

Between the tropical lines and the equator, however, the sun comes twice to the zenith of each place. If now between the going and coming of the sun, from the equator to its furthest range, a sufficient pause intervenes, or if the sun's temporary distance from the zenith is great enough, the rainy season is divided into two portions, separated by a lesser dry season. Closer to the tropical lines, where the sun remains but once in the zenith, the rainy season is a continuous one. The order of the tropical rains is thus as follows:

1. *The belt of calms*, with rain during the whole year, strongest in March and September, extending from 4° N. to 4° S. of the equator.

2. *The interrupted rains*, with rain at each period when the sun passes the zenith, extending from 5° to 15° of lat. in each hemisphere.

3. *The continuous rainy season*, during the time that the sun is in the zenith, extending from 15° to 28° of latitude.*

These conditions hold good as well on the sea as on land. The observations of travellers and resident missionaries in Africa, collected and arranged by A. Mühlry, † show the most satisfactory agreement with this theory. The belt of calms here occupies, generally speaking, the zone between 3° S. lat. and 5° N. lat., becoming somewhat wider on the west coast: north and south of this the rainy season corresponds to the arrival of the sun in the zenith; it happens thus during our summer in the northern hemisphere, and in our winter in the southern. The swelling of an African river is, however, dependent upon the rains, and thus from the observation of the time of the increase, an indubitable conclusion may be drawn as to the climatic zone in which its sources or feeders lie. If a tropical river has its flood water in our summer, its sources cannot lie in the southern hemisphere, and inversely.

Applying this key to the present investigation, we can with the greatest certainty predicate that the Lualaba, which has its sources between 10° and 12° S. lat., will have its greatest volume in our winter, and will be at its lowest stage during our summer; for this truth, besides, we have Dr. Living-

* Dr. J. Hann, in 'Allgemeine Erdkunde, bearbeitet von Dr. J. Hann, Dr. F. von Hochstetter und Dr. A. Pokorny,' Prag, 1872.

† "Ueber die richtige Lage und die Theorie des Kalmengürtels auf den Continenten: Afrika" ('Zeitschrift der Oesterr. Gesellschaft für Meteorologie,' 4. Bd., 1869, p. 155 et seq.).

stone's direct testimony. After he had discovered Lake Moero, through which the Lualaba flows, on the 8th November, 1867, and had travelled along its eastern shore to the town of the Cazembe, where he remained for forty days, Livingstone turned to go towards the Tanganyika in about January, 1868, but was compelled to return on account of the floods. "A native party came through and described the water as often thigh and waist deep, and sleeping-places difficult to find. This inundation lasts till May or June."

As Burton and Speke report that in the middle region of the Tanganyika the rainy season lasts from September to May, so Livingstone relates that on the Liemba, the southernmost part of the Tanganyika, from the 12th of May to September, 1867, no rain had fallen; and in Manyuema Land, west of Tanganyika, in about 5° S. lat., the full rainy season began in November, and continued till July, although with intervals, marking the passage of the belt of calms.

In the following summary these accounts given by Dr. Livingstone relative to the Lualaba are compared with the previously available information on the periodical rise of the rivers under discussion, already in part collected by Dr. Barth.*

	Begins to Rise.	Highest Water.	Decreases.	Lowest Water.
NORTH—				
Bahr-el-Jebel at Gondokoro.	May, sometimes in February.	Aug. and Sept., sometimes even in May.	October ..	Jan. and Feb.
Bahr-el-Ghazal	.. ..	Aug. and Sept.	October ..	Mar. and Apr.
Uelle	April.			
Shari	March	September ..	.. ..	Jan. and Feb.
Benué	May	Aug. and Sept.	October ..	Mar. and Apr.
SOUTH—				
Ogowai	Sept. and March	Oct. and April	Nov. and June	July.
Congo	November ..	Dec. and Jan..	April	July and Aug.
Lualaba	November ..	January.		

This collection of actual observations shows that the river of Gondokoro, like the Ghazal, the Uelle, Shari, and Benué, have their highest water in our summer, and that therefore their feeders are mainly situated in the northern hemisphere, although the earlier risings of the Bahr-el-Jebel, and of the Shari, indicate that their basins extend into the belt of calms. The outflow of the Lualaba—which, on the other hand, has its high water in our winter—into any one of these rivers of the northern hemisphere is therefore impossible.

The Ogowai shows, by its plainly-marked double equinoctial times of high water, and by the season of its lowest state, that it has its tributaries in the belt of calms and in the region bordering on this to southward, not far from the equator. In this it offers a contrast to the Lualaba, not, indeed, so distinct as that of the Nile and Shari, but still very remarkable.

The Congo alone corresponds in the time of its rise with the Lualaba.

* 'Zeitschrift für Allgem. Erdkunde,' xiv., 1863, p. 101, Table.

(4.) *Concluding Remarks.*—From the foregoing discussion it does not absolutely follow that the Lualaba is a branch of the Congo, because it might fall into an inland sea or lake without an outlet. Since the President of the Geographical Society of London expressed this conjecture, English geographers have shown that an inland lake can hardly be supposed to exist in the damp equatorial zone, for the reason that the enormous volume of the Lualaba, as well as of the other waters which are tributary to it, cannot all evaporate. Such a lake would of necessity be a vast inland sea, a second Caspian at the least; but a sea of this size, with its surrounding drainage basin, would take so much from the area still to be disposed of (that is, not yet known) that no space in which the Congo could collect its giant waters would remain for it. As yet there is not the smallest evidence, not even a report, of the existence of an inland sea without outlet; the assumption of such a feature then seems quite superfluous, so much the more that all existing observations, as above noted, indicate a connection between the Congo and the Lualaba, and since the native reports confirm this view in many ways.

Livingstone himself learned from a native who had accompanied the Portuguese expedition to the Cazembe, that it was believed that the Luapula (the Lualaba before it passes Lake Moero) flows to Angola. Further, it was reported to him, that the great River Loeki (in position and name probably identical with the Loke or Kassabi) flows through Lake Lincoln to the Lualaba; that the latter, passing thence by Nyangwe, where Livingstone saw it (in 4° s. 25° e. Greenwich), reached a great unvisited lake with many inhabited islands, emerging from that to form great marshy lagoons.

Ladislaus Magyar,* who followed the Loke or Kassabi to a lower point than any other traveller, heard that this river takes an easterly direction in its lower course, and attains a breadth of several English miles; maintaining, however, the freshness of its waters, and becoming dangerous for navigation at some seasons of the year on account of its high waves. It is also reported to fall into a lake. This lake was thought by Magyar to be identical with the Nyassa, the only lake of East Africa known at that time by report; but his information agrees very closely with Livingstone's reports, as well with his latest description of the Lualaba and Loeki as with his former account of the connection existing between the Kassabi and the Congo.†

Magyar further states,‡ that "the Congo rises, as I have convinced myself by reports, in the interior of Africa, on the high plateau of Moluwa, under 5° and 6° s. lat., and 25° to 26° e. long. Greenwich, in the country of Lubá, in a swamp named Inhan-ha. Uniting with the many streams of this region, at a distance of about five days' journey (from the swamp), it becomes a deep though narrow river, which flows to westward, through a level country covered with dense forests, whose frequent streams coming from north and south are taken up by the river; then it bends north-westward, under the name Kuango," &c. Now we know, indeed, from Livingstone, that the sources of the Congo cannot lie in the given position, and that these must be sought much further to south-east; but the swamp of Inhan-ha may be the marshy lakes of Livingstone; and in any case Magyar's reports trace the Congo to the region which is included in the Lualaba drainage.

Taking everything into consideration in the present state of our knowledge, there is the strongest probability that the Lualaba is the head stream of the Congo, and the absolute certainty that it has no connection with the Nile or any other river of the northern hemisphere.

Through this certainty, and by reason of the discovery that the Tanganyika has nothing to do with the Nile system, the greatest problem of African

hydrography, the question of the Nile sources, is in the main solved. That Livingstone has indirectly given the clue to this solution, must recompense the great traveller for having missed the actual Nile sources in exploring the Congo.

Speke's views have been splendidly confirmed; the attacks of his opponents, specially of Burton, who was most inimically inclined towards him, collapse into nothing. Whether the Victoria Nyanza is one lake or several is a point of detail of less importance. The reports obtained by Livingstone, who can have no knowledge of what has been recently written on the subject, are, if anything, favourable to the *unity* of the Victoria Nyanza (Ukerewe, Ukara), because along with it he names only such lakes as were already known to have a separate existence from it.

The main point of interest, and the greatest gain from Livingstone's new explorations, is that we now know that the White Nile springs in 3° n. lat. out of the Mwtan (Albert Nyanza), which receives its main tributary from the Ukerewe (Victoria Lake). Its southern water-parting is formed, 1stly, by the Ulegga Mountains, rising to 9000 or 10,000 feet in the west of the Mwtan, and stretching southward as far as Manyema Land (in about 3° s. lat.); 2ndly, by the mountains in the north of Tanganyika, which rise in Mount Mfumbiro, also to 10,000 feet; and 3rdly, by the plateau of Unyamwesi, so that no part of the Nile basin extends beyond 3° s. lat. At the western and south-western bases of the Ulegga Mountains, as well as to westward of the high land in which the Tanganyika is sunk, there begins a lower-lying plateau, rich in forests and streams, with a numerous population belonging in race to South Africa, separate and distinct from the inhabitants of the Nile valley and the east coast; with flora and fauna, which by characteristic types—the oil palm and the gorilla for example—ally themselves with those of the west coast.

Schweinfurth, as well as Livingstone, has crossed into this western interior region of Equatorial Africa, passing over the watershed of the Bahr-el-Ghazal to the basin of the Uelle; but the closer examination of this newly-opened region of Africa may be left for another paper, in which its features will be treated of in connection with Dr. Livingstone's latest journey.

The most important goal of African research is now undoubtedly the Congo; it appears in very truth to be the "Moienzi Enzaddi," as the natives named it, to Captain Tuckey, "The Great River," the river which swallows up all the others. The supposition that he might after all be on the Upper Congo seems to have often arisen in Livingstone's mind; and he says bitterly, "Who would care to run the risk of being put into a cannibal pot and be converted into blackman for anything less than the grand old Nile." Now, however, that through Livingstone and Stanley the last doubts of the accuracy of Speke's views are set at rest, the Congo remains the most worthy, the most promising, object of African exploration.

Mr. F. GALTON said that all who had taken an interest in the progress of African discovery must feel delighted that the Congo was at length to be explored. The paper that had just been read seemed to be convincing in most particulars, but somehow it missed an important point. He did not think it proved its case. It stated that the rise of the waters of the Congo must be due to the rise of the Lualaba, because the risings were nearly simultaneous. The fact, however, was that the Congo rose before the Lualaba, namely in September, while the latter rose more than a month later, namely in November, and it would require an additional fortnight or three weeks for the rise in the latter river to be felt 500 or 600 miles off in the Congo. Another peculiarity of the Congo was that it commenced to rise before the rains reached its mouth, although that part of it is more to the north than

* 'Geogr. Mittheilungen,' 1860, p. 230.

† *Ib.*, 1870, p. 192.

‡ *Ib.*, 1857, p. 190.

are the known parts of the Lualaba. Captain Tuckey found that it rose in September when the sky was only slightly overcast, and the actual rains did not begin till a fortnight or three weeks later. This fact seemed indubitably to point out that the water in the river came in some degree from the country to the north of its mouth, and was easily accounted for by supposing that the Lualaba took a sweep northward before it became the Congo. The later rise of the Lualaba would then cause the continuance of the rise of the Congo, whose long period of high water was one of its peculiarities. The connection with the Lualaba could not account for its early rise unless there was a northern bend.

Mr. FINDLAY said, according to all accounts, Tanganyika was a freshwater lake and must have an outlet, although none had as yet been discovered. It was a singular coincidence that he should in 1867 have made it exactly the same elevation as Livingstone, and also the same as that of the Albert Nyanza, but the elevation of Sir S. Baker's Lake was not as yet quite decided. He had thought that a small error in the observations might have slightly still raised the Tanganyika, and thus raised the Lualaba and the unvisited lake, and that a correction of that error might make the two lakes to coincide; but, after due consideration, he had given up that opinion on account of the dates of the rising of the waters and the comparison of the volumes. The rising of Tanganyika was identical with that of Albert Nyanza, and, therefore, although the northern end was closed, he did not think the question of the disposal of the waters of Tanganyika was yet settled. No doubt the southern end, too, had been closed by Livingstone's explorations. Nothing was known of an eastern outlet, and it would be very singular if there were one, because it would be in opposition to the course of the Malagarazi. Mr. Stanley stated that he heard the sound of a large waterfall (or surf) on the western side, which could not be far from Ujiji. It might be that there was an outlet on that side to Baker's Lake. It was to be hoped, however, that the whole question would be soon settled by exploration, and thus render speculations unnecessary.

Colonel GRANT said he regarded the separation of Livingstone's discoveries from the source of the Nile as a great triumph for his late companion Captain Speke. Some four or five years ago, Livingstone wrote home to say that he had come upon the source of the Nile in 10° or 11° s. latitude. He (Colonel Grant) had, however, felt convinced that these sources of Dr. Livingstone had nothing whatever to do with the Nile, and the despatches which had lately reached England confirmed him in this opinion; namely, Livingstone mentioned having seen the skulls of gorillas, that the women of Manyema, or near there, dive in the water and bring up oysters, et cetera; but throughout Captain Speke's journey, the gorilla was never once met with, though heard of to the west of it; such a custom as the women of the Nile region diving was never seen nor heard of, and oysters in the centre of Africa are of course an impossibility, although large bivalve shells of a new species were brought home from Tanganyika by Speke. Another remarkable custom is related in Dr. Livingstone's letters, that the inhabitants about Manyema domesticate pigs: this at once indicates a strange race; for though the people of Nile-land hunt and eat the wild boar, they do not keep it in a tame state, and the Mahomedan races far down the Nile are forbidden by their religion to defile themselves with this animal. If a reference be made to Captain Tuckey's Travels on the Congo, these customs of women diving and the domesticating of pigs will be found recorded. From these facts he (Colonel Grant) had formed his opinion that Speke's Nile was distinct from Dr. Livingstone's discoveries, and, since hearing the paper of to-night giving the comparison of the Lualaba and Nile volumes of water, this opinion received additional confirmation. He protested against the new form of three lakes given to the Victoria Nyanza

in the two maps before the audience, as Dr. Livingstone's recent explorations had not extended to it, and certainly proved the accuracy of Speke's observations on the Tanganyika Lake; namely, though Burton and Speke did not arrive at the extreme north end of Tanganyika, Speke made the river run into the lake because mountains surrounded its northern shore. Livingstone and Stanley have confirmed this geography. Who, therefore, was the real discoverer of the waters flowing into the lake, Livingstone, or Stanley, or Speke? As regards the Victoria Nyanza being one body of water, he felt convinced that future explorations would prove it so; for though Speke himself did not go round more than one half of it; still they saw its boundless surface, its sea-horizon, the moon rising out of the lake, and no native had ever crossed it, and none knew what races lived upon its opposite shore.

The Rev. HORACE WALLER said the intelligence that an Expedition was about to start for Western Africa would be new to the public generally. Dr. Livingstone's old friend, Mr. Young, whose great generosity had enabled them to prepare the Expedition, had entered into the subject very closely, and the real object of his making such a liberal gift was to relieve and help Livingstone, whom he considered to be entangled in the middle of the country with an enormous quantity of water to deal with, and for the moment not knowing which way to turn to look for the outflow. These were times when it was best to be candid and speak out, for to some people it might seem that the Society was going to take advantage of what Livingstone had stated in his letters, and to claim for itself new discoveries and new glory. Nothing, however, could be further from their intention, or from the intention of Mr. Young in making his gift. The Expedition was solely and wholly to aid Livingstone in his discoveries, and they were most fortunate in securing the services of a gallant naval officer to whom the subject under consideration had long been a matter of careful study, and who was willing to go out as the lieutenant of his commanding officer Dr. Livingstone. Whether he met him or not, whether he was able to trace the Congo to the Lualaba or not, he would, on his return, lay the account of his discoveries before the Society, and offer them as a contribution to the labours in which Livingstone had been so long engaged in Central Africa. It was a matter for thankfulness that at last public interest was aroused with regard to Central Africa, and if Livingstone could know that those letters, which had reached England owing to Mr. Stanley's determination and courage, had really been the means of crushing out the slave-trade, he would feel a young man again. It was a matter of surprise to many, that with so many young men with large fortunes in England—men fond of exploring, fond of sport, and with glory enough to be obtained—so few were found to visit Africa. He hoped that the work now begun would be carried on, and that there would be a steady flow of explorers from England. There was no danger in exploring. The only danger was in standing still, and, as a matter of fact, hardly one man had lost his life whilst busily carrying on explorations.

The PRESIDENT proposed a vote of thanks to Mr. Young for his noble gift. Undoubtedly his object was the relief and support of Livingstone, and it was entirely in accordance with his views, and in deference to his wishes, that the Society was going to send out Lieutenant Grandy. They did not intend to arrogate to themselves any credit for originating the Expedition, or utilising the fruits of it; but they trusted it would be of service to Livingstone, and any contributions which might be gained to geographical knowledge would be gratefully received.