carry their classes beyond the matriculation examination of the university, which thus serves as a general leaving examination, and when their pupils have passed it there is nothing for them to do, if they wish to prosecute their studies further, but to go on to college, however young and crude they may be. So long as the present university system endures it is difficult to foresee any remedy for this. The university does not demand of its candidates for the higher examinations that they should have been trained at a college, and were the schools to develop advanced classes they would merely compete with the colleges in teaching for the intermediate degree examination, the standard of which would be still further lowered. What is wanted is a system of secondary schools entirely independent of any university, the pupils of which would not be sent on to college until they had reached a decent maturity. As things are, the whole educational system of the colony is absolutely subject to the tyranny of external examinations, and for this the university is chiefly responsible.

So unsatisfactory a state of affairs cannot endure much longer. The only radical cure for it is one which Mr. Rhodes attempted to bring about years ago, the institution of a single teaching university in Cape Town. (The eastern province is not yet sufficiently developed to support a separate university, but in view of its great distance from Cape Town the college at Grahamstown might perhaps remain as an affiliated institution until it is strong enough to stand alone.) Such a teaching university Mr. Rhodes would have endowed, and even though, through local jealousies, the chance of his munificence has been lost, his plan remains the wisest and even the most economical. The Government is remarkably liberal in the cause of higher education. It pays, usually up to a limit of 200*l.* a year, half the salary of all professorships or lectureships the institution of which it approves; it pays half the expenses of general maintenance, and issues loans in aid of building schemes on very favourable terms. In the case of colleges which confine themselves to work above the standard of matriculation and have not less than seventy-five matriculated students—*i.e.* at present in the case of the South African and Victoria colleges—the grants in aid of salaries may be increased up to a limit of 350*l.* The public expenditure on behalf of higher education is thus very considerable, but it is dissipated among several centres, and the benefits accruing from it are necessarily less than they would be were it directed to the support of a single teaching university.

Unfortunately, this ideal is even more unlikely of achievement now than it was in Mr. Rhodes's lifetime. Public opinion remains inert, but the colleges have grown, and it would be almost impossible, and probably undesirable, to force them into reluctant amalgamation. Yet something must be done. The country colleges would prefer probably the conversion of the present university into a federal system of constituent colleges, a policy which has, of course, been tried elsewhere, but without much success. In Cape Town, on the other hand, the feeling is growing that, even though other centres may stand aloof, the city itself should do its best to realise Mr. Rhodes's purpose by founding a teaching university. In the South African College it has the means of doing so, and when that institution has completed its present scheme of development its just claim to independence could not be refused. Nothing could be more beneficial to the colony than such a university in Cape Town with well staffed and well equipped professional schools attached to it. Not only would it raise the general standard of education, as no merely examining body can, but it would draw together and train together the best intellects among the youth of the country, and would thus prove an invaluable factor in the work of uniting the races. No doubt it is a costly scheme, and since the Government cannot concentrate its support of higher education, but will have to continue to assist some at any rate of the local colleges, a great part of the burden must fall on private benefactors. But at the Cape itself to arouse enthusiasm for a great ideal should not be difficult, and it may even be hoped that among the men of millions "who live at home at ease," and who are at last beginning to appreciate the dessert of universities, some may be found willing to assist a scheme which is not the less deserving because it is South African.

## *THE BATOKA GORGE OF THE ZAMBESI.*[1]

WHEN I undertook to examine the geological structure of the country around the Victoria Falls on behalf of the council of the British Association, it appeared to me that there were two essential matters on which our information was very inadequate. The first was with respect to the origin of the falls themselves and the singular gorge associated with them, and the second as to the course of the great river for 70 or 80 miles below the falls. The opinion of David Livingstone, stated fifty years ago, that the gorge must have been formed by the sudden opening of a zigzag crack in the earth's crust, had been adopted without question by all subsequent travellers, although hardly anything was known of the cañon beyond the immediate vicinity of the falls.

Before I left England last June, however, a timely store of new information was forthcoming that materially lightened my task. In an able article on "The Physical History of the Victoria Falls" (*Geograph. Journ.*, January), Mr. A. J. C. Molyneux, of Bulawayo, produced strong evidence to prove that the majestic waterfall and its concomitants have been slowly developed by the erosive power of the Zambesi itself. With regard to the course of the river below the falls, unpublished information was most courteously placed at my disposal by the authorities of the British South Africa Co., which showed that a distinguished officer of the company, Mr. F. W. Sykes, the District Commissioner at Livingstone, had succeeded three years ago in penetrating the hitherto unknown country bordering its northern bank for some 40 miles to the eastward of the falls. The report on this journey prepared by Mr. Sykes, and the beautiful photographs by which it was illustrated, were sufficient in themselves to explain the ruling features in the physiography of the district, and incidentally afforded further testimony in favour of Mr. Molyneux's conclusions.

During my own examination of the district in July and August last, I had the inestimable advantage of the personal guidance of Mr. Sykes in my traverse of the country on the northern side of the river from Victoria Falls to Wankie's Drift. In this traverse we were accompanied by Colonel Frank Rhodes,[2] and for part of the distance by Lieut. Burgin, in command of a detachment of native police. The journey entailed a devious and somewhat arduous march of about 120 miles across an almost trackless country, consisting mainly of rugged stony ground covered with low trees. Wankie's Drift appears to lie considerably to the eastward of the position assigned to it on existing maps, its distance in an east-south-easterly direction from Victoria Falls being probably not less than 75 miles as the crow flies.

Our route was roughly parallel to the course of the Zambesi, at first south-eastward for about 20 miles (in a direct line), then toward east-north-east for a further 35 miles, until we crossed the Ungwesi or Kalomo River, and finally east-south-eastward for nearly 40 miles, to the river-crossing at Wankie's. The deep impassable chasms into which all the tributary streams are precipitated as they approach the Zambesi, and the extremely rugged character of the much-dissected ground between them, forbade any passage along the brink of the main gorge except for short distances, and our general line of march was therefore taken beyond the heads of the side-chasms, often many miles from the Zambesi itself. At four places, however, before reaching the Ungwesi, we struck southward to the main river; and at three of these we managed by rough scrambling to descend into the bottom of the gorge. Finding in these places that the ancient lavas of the surrounding plateau—the "Batoka Basalts" of Molyneux—were still, as at the Falls, the only rocks exposed in the gorge, we decided, as time was pressing, to continue along

[1] Abstract of "Report on the Batoka Gorge of the Zambesi and the Country between Victoria Falls and the Confluence of the Deka River," brought before the Geological Section of the British Association at Johannesburg on August 29, by G. W. Lamplugh, F.R.S.

[2] The news, which reached me during the homeward voyage, of the untimely death of Colonel Rhodes at Cape Town on September 21 has overshadowed the otherwise delightful memory of this journey. To have known Colonel Rhodes, the most cheery of travelling companions, at all was inevitably to hold him in affectionate regard. His deep and cultured sympathy in all that pertained to the magnificent Falls, and his efforts to maintain their loveliness unimpaired, deserve the grateful remembrance of all interested in Rhodesia.

the main route until the termination of the basalts was reached. These rocks proved unexpectedly to be continuous to Wankie's, although the "Batoka Gorge" (as it is proposed to name this cañon of the Zambesi) itself ceases 6 or 8 miles above Wankie's, giving place to an open valley with a broad shallow river sprinkled with islets.

On ferrying in a native "dug-out" across the Zambesi at Wankie's we were met by Mr. H. F. Greer, of the British South Africa Co., who holds charge in the district south of the river. Here Mr. Sykes and Colonel Rhodes struck southward to reach the railway at Wankie Coal Mine, 35 miles distant, while Mr. Greer and myself took a westerly course parallel to the Zambesi for about 60 miles, still traversing a basalt-country. We turned aside twice in this westward journey in order to examine the Zambesi valley at places eastward of those reached from the north bank. One of these was at the confluence of the Matetsi with the Zambesi, which is a little below the termination of the narrow gorge; and the other place was about 15 miles farther west, where the structure of the cañon is not materially different from that which it presents in the place where it had been last entered from the northern side of the river.

Mr. Greer having very kindly undertaken to escort me to the headwaters of the Deka River, where previous information had led me to expect that the base of the Batoka Basalts would be found, we then took a south-westerly course to Matetsi Camp. Crossing the railway there, we continued our journey westward, southward, and south-eastward across the upper part of the basin of the Matetsi River, and after some days of hard trekking struck the higher reaches of the Deka, only to find that the interminable plateau-basalts over which the whole of our route had hitherto lain were still the underlying rocks, and that the surrounding country gave no indication of structural change. It had been our intention to return from Deka to the Falls by the old traders' route past Pandamatenka and Gasuma; but as the Bushmen reported that, owing to the exceptionally dry season, no water would be found in Gasuma Vley, this plan became impracticable, and we decided to follow a north-eastward route, parallel to the Deka River for about 60 miles, to the Wankie Coal Mine. Geologically, this proved to be the most interesting part of my journey, and I therefore spent four days at Wankie in further investigation, profiting greatly from the guidance and kind hospitality of the manager of the mine, Mr. J. M. Kearney.

The basalts are cut off abruptly along the lower portion of the Deka valley by a great fault striking approximately north-east, which brings in the sandstones and shales with which the Wankie coal-seams are associated. Some fragmentary plant-remains were collected from the Wankie Coal-measures, and among these Mr. A. C. Seward has recognised Vertebraria, which indicates that the deposits are of Permo-Carboniferous age, as indeed had been previously surmised. Returning by rail from Wankie Mine to Victoria Falls, I spent a few more days in examining the head of the gorge and its surroundings, and was then compelled to leave Rhodesia in order to join the Association at Johannesburg.

The 600 miles of actual trekking that was accomplished embraces a region of some 2000 square miles, of which all except about 80 square miles east of the Deka is underlain by the Batoka Basalts. The full extent of these ancient lava-fields is still unknown, but, judging from information that I obtained, it is likely to be not less than 7000 square miles. Their thickness is also unknown, but in the lower part of the Batoka Gorge, where the original surface of the basalts must have been very considerably lowered by denudation, the Zambesi has sunk for 800 feet further through these rocks without revealing their base. In their prevalent characters they are remarkably uniform, consisting generally of thick bands of close-grained dark-blue rock alternating with red, purple, or ashy-looking amygdaloidal bands which mark off the surfaces of successive lava-flows. These less massive bands frequently show a fragmental structure, and occasionally pass into fine and coarse agglomerates suggestive of volcanic tuffs or ashes; but I think that this structure may represent the brecciation of the solid crust of the lava-flow before its onward movement had ceased, and is not indicative of true ashes. In the whole course of the journey I did not find any trace of an eruptive centre or volcanic orifice, and the rarity of dykes was also remarkable. Neither did I find any interstratified sediments among the basalts in the country traversed, though there appear to be some interstratified red and green beds of shaly aspect in the railway cuttings of the Katuna valley west of the Deka, which I had no opportunity to examine. Like similar "plateau-basalts" in other parts of the world, this immense mass of lava has probably had its origin in "fissure-eruptions," by which a vast tract was flooded under rapidly recurrent flows of high fluidity.

We still lack definite information as to the geological age of the Batoka Basalts; by Mr. F. P. Mennell and Mr. A. J. C. Molyneux they are regarded as most probably Tertiary, while Dr. S. Passarge correlates them with the Loale Amygdaloid, which he considers to be of Secondary age, perhaps Jurassic; but the evidence for either view remains inconclusive.

The surface-deposits of sand, sandy limestone, cavernous quartzite and hematite which locally overlie the basalts in this part of the Zambesi basin, though of considerable interest, must be dismissed for the present with the remark that their mode of occurrence in this region is not favourable to Dr. Passarge's view that they represent a definite order of events. The red sand (equivalent to the "Kalahari Sand" of Passarge, and probably in part to the "Forest Sandstone" of Molyneux) may, indeed, denote a period of conditions different from those now existing; but the limestones and quartzites appear to me to be due to purely local circumstances that still prevail.

Let us now turn to regard briefly the physiography of the region;[1] in which respect that wonderful natural feature, the Victoria Falls, is, of course, the main pivot of interest.

Above the Falls, the Zambesi flows sedately in a broad mature valley with low sides, excavated in the upper portion of the Batoka Basalts. The gentle slopes of this valley are partly buried under ancient desert-sands—the "Kalahari Sand" of Passarge—and all the features point to a long continuance of relatively stable conditions during which the river has done very little erosive work. On the brink of the Falls its bed is still about 3000 feet above sea-level; but at this point, suddenly, with a majestic plunge, the Zambesi begins its impulsive descent from the central plateau, and thereafter tears its way forcefully across the mountainous margin of the continent, through a succession of gorges alternating with relatively placid reaches according to the variable endurance of the rock-masses that lie in its path. It is to this rejuvenation of the river at the present margin of the plateau, and its resultant influence upon certain structures of the basalts, that, as Mr. Molyneux has shown, we owe the magnificent Falls, and not to any catastrophic rending of the earth's crust.

The Batoka Basalts are traversed by a regular and persistent system of close-set joints striking approximately east and west, and are also occasionally fractured in the same direction by still bolder vertical planes, probably representing lines of fault, that are sometimes accompanied by veins of calcite and other minerals. At the surface of the plateau the basalts are much weathered, and this weathering sinks deepest along the joints and fractures, whereby these become the lines of readiest erosion.

The rivers of this country are characterised by the enormous difference that obtains between their volume in the dry and in the wet seasons, a difference which affects the great Zambesi proportionately almost as much as its tributaries. During the shrinkage of the streams, the greater portion of their broad rocky beds is laid bare, and the water is confined within narrow gullies along the joints and lines of readiest erosion, so that for more than half the year it is in these channels only that there is any wearing down of the stream-bed, while in flood-time it is still along these gullies that the water is deepest and most forceful, and that the chief portion of the detritus (astonishingly scanty in these African rivers) is swept. Thus, granting a sufficient gradient, these dry-season channels become deepened and enlarged until they are

[1] This portion of the report was illustrated by lantern slides showing the chief features of the Gorge.

capable of carrying the flood-waters also, and the course of the stream becomes fixed along them. We found striking illustrations of these conditions both in the Batoka Gorge and in the beds of the tributaries in many places. The sudden and acute bends that are so peculiarly characteristic of the Zambesi below the Falls are in this way readily explicable.

A broad ancient river-flat, with low sloping banks on both sides, excavated across the edges of the gently dipping lava-flows, is distinctly traceable for many miles below the Falls, until obscured by the breaking up of the plateau by the gradually lengthening development of the lateral chasms of the rejuvenated tributaries. This flat is comparable in breadth and general aspect to the valley of the Zambesi above the Falls; and the presence of a few rounded pebbles upon it above the brink of the gorge gives further evidence for the former flow of the river over its surface. It is continued southward as a shallow depression in the surface of the plateau for five or six miles from the Falls, and then curves eastward.

It may be mentioned here, as a matter deserving the attention of archæologists, that rudely chipped implements of chalcedony, agate, and jasper are very abundant in many places on this ancient river-platform, and also upon the low rocky hummocks bordering the Zambesi above the Falls. A few of these implements show signs of wear as if by river-action, and may therefore possibly be of considerable antiquity. We found them, here and there, in profusion during the first 20 miles of our eastward journey, but very rarely during the later stages of the trek. A collection of these implements was exhibited at a meeting of the Anthropological Section.

The erratic zigzags of the Batoka Gorge swing to and fro within this broad depression, but without escaping from it. Even within the gorge, the river, still possessing a high gradient, tends to confine itself within narrower limits as it scoops out the less resistant portions of its bed, leaving many abandoned channels, rock-terraces, and spur-like ridges to break the severity of its cañon walls.

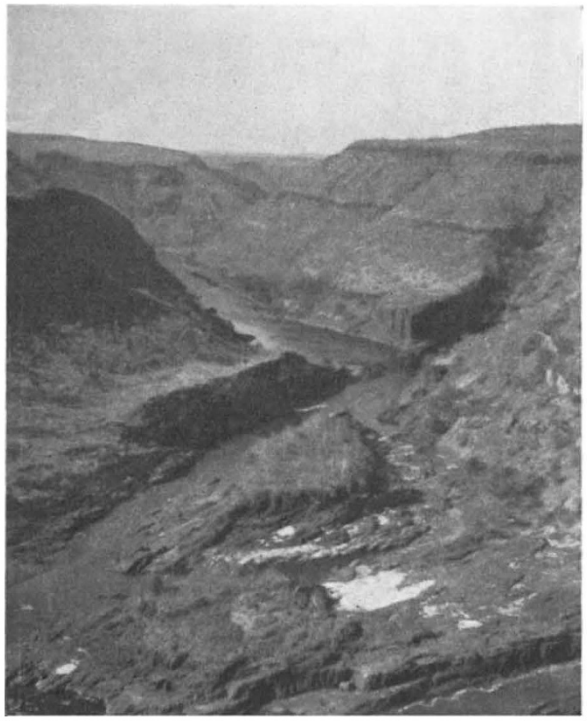
Nowhere can these features be better studied than in the left bank of the Gorge, about 7 miles below the Falls, around the confluence of the Songwe, a little tributary which has itself carved out a narrow chasm about three-quarters of a mile long and more than 400 feet deep into the margin of the plateau. As well for its savage magnificence as for its scientific interest, this spot deserves to be visited; and one may be allowed to express the hope that the responsible authorities will undertake the comparatively light work of clearing a track from the Falls, to render it accessible to the tourist.

To one whose first impressions of the Zambesi had been gained from the mile-wide river above the Falls, it was astonishing to find the whole river, at its present low stage, confined at this place within a channel not more than 35 yards in width—bordered, it is true, by a rocky scar, about 150 yards wide, honeycombed with deep "pot-holes," which was evidently submerged during the floods. After seeing it one could understand how the idea has arisen—and still lingers—that part of the Zambesi is swallowed up at the Falls into an underground channel.

But even this is not the narrowest limit within which the great Zambesi can confine itself at low water; for on reaching the bottom of the gorge at the Tshimamba Cataracts, some 20 miles east of the Songwe, we found the whole river raging tumultuously through a water-channel which, at one place, was less than 25 yards in breadth (Fig. 1). This place is apparently the only part of the interior of the Batoka Gorge that was ever penetrated by the white man until Mr. F. W. Sykes's expedition of 1902. His predecessor here was David Livingstone, who in his second book of travels tells how he turned aside on his eastward journey at the rumour of another great waterfall, and was disappointed to find, not a second Victoria Falls, but only a bold cataract, in which the river drops about 20 feet. Nevertheless, the Tshimamba also, were it rendered more accessible, would be well worth visiting, if but to see the mighty river shrunk to this little measure; and one may expect, sooner or later, to find it included within the "grand tour of the Zambesi."

Although the surface of the basalt plateau falls steadily eastward, the Zambesi within its gorge sinks somewhat more rapidly in the same direction, so that while immediately below the Victoria Falls the river is barely 400 feet below the lip of the gorge, this is increased to about 500 feet at the Songwe, to about 600 feet at the Tshimamba, and to 800 feet at the place some 35 miles farther east which we reached from the south bank. Aneroid observations showed a difference of more than 900 feet between the level of the river at the foot of the Falls and Wankie's Drift, which represents the descent of the water in passing through the Batoka Gorge; and until this steep gradient is very much reduced the Zambesi must continue to deepen its channel along the easiest lines before there is time for it to straighten out the angularities of its course.

The results attained by this selective erosion are strikingly exemplified in the immediate surroundings of the Victoria Falls. The wonderful Chasm, in places only 80 yards wide, into which the broad river is here precipitated, owes its chief features to the presence of an east and west vein, probably a fault-plane, that cuts vertically through the basalts. This vein, which I found to be well exposed in the steep Recess or gully at the eastern end of the Chasm, is partly filled with calcite and other soft vein-stuff, and the rock adjacent to it is shattered and readily decomposed. When the falls, in receding northward, struck upon this vein, they readily hollowed out a transverse trench across the whole breadth of the river, from which the waters escape southward through a single narrow channel. But, having passed this easy place, it is becoming increasingly difficult for the shallow river to support a fall of its full width, and consequently the wearing back of the lip is at present progressing most rapidly in a comparatively narrow space at its western margin. Here the "Leaping Water" pours a strong flood perennially into the corner of the Chasm, and may eventually concentrate the whole of the river into its trough, unless, as Mr. Molyneux has suggested, the deep oblique cleft that is being rent across Cataract Island should gain precedence

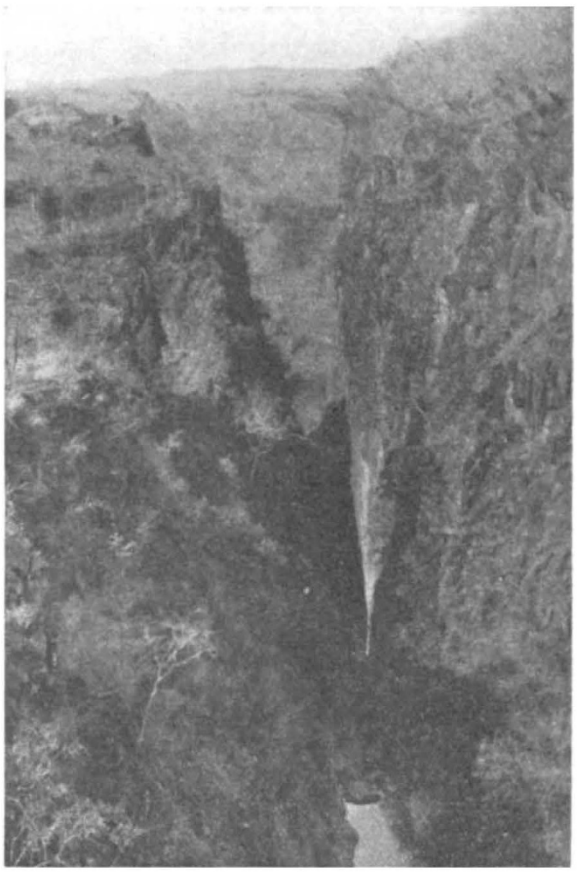


*From a photograph by Mr. F. W. Sykes.*

FIG. 1.—The Gorge immediately below the Tshimamba Cataract. The depth of the cañon here is about 600 feet. The Zambesi, in the foreground, is confined in a channel from 20 to 25 yards wide. Note how the strong jointing of the basalt governs the course of the river and tends to produce zigzags in the low-water channel.

in the backward race. The narrowness of the cañon below the falls, as compared with the breadth of the river above them, shows that only by such concentration has the Zambesi been enabled to tear out its gorge so far back into the plateau.

Mr. Molyneux has rightly laid stress on the behaviour of the tributaries as proof of the erosive origin of the Batoka Gorge. Above the Falls the tributaries have so nearly reached their base-level relatively to the Zambesi that they hold deep back-waters where they join the main river, of which the Maramba, 2 miles from the Falls, presents a good example. But below the Falls they have at first been left in shallow open "hanging valleys," high above the main artery; and thus rejuvenated by a sheer drop of 350 feet or 400 feet, each little stream has begun to work vigorously backward into the



*From a photograph by Mr. F. W. Sykes.*

FIG. 2.—Kalonga's Cleft on the Karamba River. The walls are about 300 feet high.

plateau along its own line of drainage. Each waterfall tends to recede farther and farther within its own precipitous rift as we followed the Zambesi downward, so that while at first it was possible to round the heads of these by a detour of a few hundred yards, we found that farther east not only do they extend far back into the plateau, but many minor clefts branch out from them, rendering the country a maze of dangerous chasms. In these waterfalls and rifts the salient features of the main gorge are often reproduced in miniature. The most remarkable example that we visited occurs on the Karamba, a stream which joins the Zambesi about 35 miles east of the Falls. Some 5 miles above its junction with the Zambesi this stream drops by a waterfall from its open shallow valley into a gloomy recess, from which it escapes by swerving at a right angle between nearly vertical rock-walls, 300 feet in height, through a cleft only 15 feet to 20 feet in breadth (Fig. 2).

If further proof for the erosive origin of the Batoka Gorge be needed, I would direct attention to the gradual falling off in the angle of slope of its sides as we descend the river. At the Falls, where the gorge is freshly cut, its walls are practically vertical; but a few hundred yards below they are already beginning to show the effect of weathering by a slight recession of their crest-line and by indications of terracing along the planes of stratification. At the Songwe confluence, 7 miles farther down, this recession and terracing have become so pronounced that the average angle of slope from base to crest is reduced to 60° or less; at the Tshimamba, about 30 miles below the Falls, it is no more than 35°; and at the mouth of the Karamba, 12 miles farther east, the sides of the gorge have been weathered down into bushy slopes, broken here and there by inconspicuous bars of crag, with an average inclination of about 30°, which is also the character of the cañon at the place where it was visited still farther eastward.

If time had permitted, I should have liked to discuss the curious difference between the broad basin of the Matetsi and the narrow trough of the Zambesi within the basaltic plateau, which presents an important problem in the physiography of the region, especially when we remember that the Batoka Gorge terminates at a short distance above the confluence of the Matetsi; but this would open up too wide a subject for the present occasion.

In the face of all the evidence we must conclude—not without a tinge of regret—that the Batoka Gorge can no longer be allowed to stand apart, a unique curiosity, among the valleys of the earth—that no exceptional forces have been brought into action to produce its wonders and its loveliness—but that the everyday effects of river and rain, with time—that indispensable factor to the geologist—a very long time—are ample to explain all its marvels, as they have already explained the marvels of many another noble cañon of the world.

I must not let pass this opportunity of expressing my gratitude for the kindness shown to me by the officers of the British South Africa Company in Rhodesia and also in London, by the engineers of the Wankie Coal Mine and of the Rhodesia railways, and by many other friends in Rhodesia. To Mr. F. W. Sykes I am peculiarly indebted for removing difficulties that, except for his self-sacrificing cooperation, might have proved insuperable.

G. W. L.

## *INDIAN DEEP-SEA HOLOTHURIANS.*[1]

THE most recent addition to the list of publications issued by the Indian Museum, Calcutta, deals with a collection of deep-sea Holothurians made by the survey ship *Investigator*, which has rendered valuable service in the interests of deep-sea research. The extreme utility of this work, which will help to elucidate many of the problems connected with deep-sea life, is enhanced by the fact that the investigations have been carried on over comparatively unknown ground, so far as the great depths are concerned.

The area examined by the *Investigator* is a comparatively wide one, and ranges over the northern part of the Indian Ocean from the Persian Gulf to the east side of the Bay of Bengal.

Most of the deep-sea expeditions appear to have confined their labours to the Atlantic and Pacific Oceans, and even the *Challenger* did not touch the northern part of the Indian Ocean. The *Siboga* Expedition reached the extreme south-eastern portion of the *Investigator* area, and a comparison of the *Siboga* Holothurians with those in the paper under notice provides an interesting study, and, incidentally, confirms the opinion that a knowledge of the distribution of deep-sea forms derived from an examination of isolated areas is apt to be misleading.

Of the seventy-five species and varieties described in the report, no less than sixty are new to science. The Synallactidæ appear to be the predominant forms amongst the deep-sea Holothurians of the Indo-Pacific region, both

1 "An Account of the Deep-sea Holothurioidea collected by the Royal Indian Marine Survey Ship *Investigator*." By R. Kœhler and C. Vaney. Pp. 123; 15 plates. (Indian Museum, Calcutta, 1905.)