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THE STRUCTURE OF SOUTHERN NIGERIA.*

By JOHN PARKINSON, B.A., F.G.S., Principal of the Mineral Survey.

IN the following pages I have endeavoured to give some account of the structure of Southern Nigeria, dealing, in the first place, very briefly with the geology of the country, and in the second with the salient features of the physiography. The intimate relation existing between these two sub-heads need not here be emphasized.

Since the winter of 1903, various journeys have been made by the Mineral Survey of Southern Nigeria, working under the Colonial Office and the Imperial Institute, for the purpose of ascertaining the mineral resources of the colony. In so brief a time and in so large a country, it will be obvious that a complete examination is impossible, and, moreover, it should be borne in mind that much of the north-eastern corner of the colony adjacent to the Kameruns boundary, and including the headwaters of the Katsena, has not yet been brought fully within the sphere of British influence. This tract of unexplored and unknown country extends westward as far as the Niger, and it is possible that a later survey of this very large proportion of the colony may modify some of the statements hereafter made.

No part of the district lying between the Cross river and the Niger has been visited by me, and the following remarks apply, firstly, to the region of the Oban hills and the valley of the Cross river, so far as this is contained in British territory; secondly, to a traverse from Sapele northward, through Benin city, Ifon, and Owo, to the Northern Nigeria frontier; thirdly, to the district around Asaba; and fourthly, to certain parts of the Lagos province, especially the Ijebu country. The routes taken are marked on the map.

In order properly to understand the structure of Southern Nigeria, it is necessary to realize the position and extent of the old floor of crystalline rocks now exposed at the surface. The members of the geological series found in Southern Nigeria are but few, and of these the granites, gneisses, and schists are by far the oldest. Upon their worn and eroded surfaces all the later sediments were laid down, and although it cannot be truly said that they invariably produce a distinct type of scenery, there can be no doubt of their fundamental importance as factors in producing the physiography of the colony. The nature of these sediments depends on the distance they were deposited from this old land surface, while the positions and magnitudes of bucklers of crystalline rock must have modified greatly the form and extent of the foldings subsequent to their deposition. To both of these factors the scenery is directly related. The southern boundary of these old rocks runs from Abeokuta, eastward and a little south of 7° N. lat., but near the Niger turns northward, crystalline rocks being first seen, according to Gürich, at 7° 19' N. lat. To the east, as will be seen from the map, a large hiatus appears over the unknown country referred to above, and the rocks are not found again, with certainty, until we arrive in the neighbourhood of the Oban hills.

The researches of Solger,† Esch, and others have proved, not only the occurrence

* Read at Section E, Geography, York Meeting of the British Association, August, 1906.

† With the exception of some phyllites and grits near Uwet. These rocks may have a greater subterranean extension than is at present known.

‡ 'Geologie von Kamerun,' and numerous papers.

of closely similar gneisses and schists in the Kameruns, but also representatives of the Mesozoic and Tertiary sediments, so that in all save its volcanic phenomena the Kameruns may be considered as having shared in the geological history of Southern Nigeria.

Following the crystalline rocks in importance, the Cretaceous system is, in my opinion, the most noteworthy of the later sediments. Sweeping round the old shore-line of the Oban hills, these rocks, with a few small exceptions form the banks of the Cross river, often low and monotonous, but now and again, as near Itu and Ungwana, rise into bold ridges.

My work has not taken me further up the Cross river than Itaka, about 10 miles below Abokam, on the Kameruns frontier, and at the latter town we reach, I believe, the limit of the Cretaceous rocks, which, however, certainly extend northward up the Aweyong river at least as far as the entrance of the Moya creek. They have also been traced from Afikpo to Abakalliki,* and doubtless extend for some distance to the west and north. So far they have not been found in Southern Nigeria west of the Niger.†

While the type of country produced by the Cretaceous sediments does not greatly differ in some instances from that of the crystallines, yet in other districts, *e.g.* Afikpo, we find a very characteristic relief. On the other hand, the third or Tertiary member of the tripartite division into which for present purposes we have divided the geological series, forms typically a country of low relief, usually gently undulating. Such a country is characteristic of the southern parts of the Lagos and Central Provinces. Beds of different ages are doubtless included among the Tertiary rocks, but the most conspicuous is the red sand or clay which is found almost everywhere in the neighbourhood of Benin, forming the series which I propose to call the Benin Sands. The prominent hills of Adiabo and Calabar, prominent because of the swamps by which they are surrounded, are formed of these red sands; they compose many of the rounded ridges near Asaba, and form the surface soil of much of the Ijebu country.

It may be well at this point to remark on the great difficulty presented to the geologist and physiographer alike by the dense forest which covers a very large part of Southern Nigeria. It is only too rare that from a suitable elevation outlooks over the surrounding country may be obtained, and while we may from such positions study the rounded knolls and ridges of the Kukuruku hills or the sharper and more abrupt peaks of the Obans, when once plunged in the bush we are buried in a tangled mass of creeper-laden vegetation, unable to see 30 feet before or behind, or even to follow with the eye the stream which we hear plainly below us in the valley. I venture to think that few can realize what a handicap to research the forest is until they have personally experienced the way in which it hides rocks and valleys alike.

In addition to the three types of country formed by the three geological divisions, we have the very well-marked type of the mangrove belt of the delta and coast. Neglecting these swamps, which have been described elsewhere, the scenery of the three principal types will be outlined in order.

Taking firstly the crystalline rocks, we note the massif of the Oban hills on the east differs in many points from that of the Kukuruku and associated hills of very similar type on the west. With the latter we may group the gneisses and schists of Ibadan and Abeokuta, with which they are most probably continuous, and

* N. lat. 6° 19' 18", L. H. L. Huddart; E. long. 7° 0' 0".

† Probably an exception occurs on the right bank of the Niger opposite Ida.

endeavour to compare the two areas. Owing to varying distances from the sea, and partly, perhaps, to difference in latitude directly affecting the vegetation, the traveller is struck at first more with the relatively sparsely forested character of the Kukuruku as compared with the Oban hills, though the deeply incised mass of the latter cannot fail to impress him.

From the physiographical point of view the Oban hills are a study of some difficulty. Speaking generally, they may be described as a collection of unorientated hills, culminating to the east-south-east of Ibum in a group of peaks rising to 3000 or 3500 feet above sea-level, the whole characterized by exceedingly steep slopes. There is distinct evidence of a radial drainage system, which on additional mapping will, I believe, become still more obvious, originating from the high group of peaks just mentioned, while the main watercourses are exceedingly tortuous and encumbered by rapids and small falls. During the dry season (say November to March) these streams, so far as I know, are fordable almost at any place, while the occasional rise during the rains cannot be much under 25 feet above the March level. An estimate* by aneroid of the fall of the main stream of the Calabar river for 5 or 6 miles above Uwet is 50 feet to the mile; the constant rapids by which this river, in common with the others of the Oban hills, is encumbered do not however, extend beyond the boundaries of the crystalline rocks. The lowest rapids of the three southward-flowing streams (the Calabar, the Kwa, and the Akpa Iyefe) draining the Oban hills lie almost in a straight line, and mark nearly, though they are always a variable distance above, the line of boundary between the crystalline and sedimentary rocks. In the case of the Calabar river the distance is about a mile, in the Kwa about 5 miles, in that of the Akpa Iyefe about $1\frac{1}{2}$ mile. We may perhaps assume that these falls originally formed on the actual junction, and that each has worn back so that the line of rapids now stands to the north of its original position. The valley-sides throughout this district are steep; two measurements of the slope of the Calabar river south of Ibum give angles of 30° and 33° respectively, that of the banks of the Kwa near Abuton 41° .*

A discordance in grade between the tributaries and main streams leads to the formation of hanging valleys, of which typical examples may be seen near Uwet and Abuton, as well as in the hills themselves. The usual explanation of elevation initiating greater erosion of the main valleys with which the tributary streams are unable to cope, seems applicable here; but the history of the drainage system is complicated by the uncertainty as to whether the Cretaceous strata ever entirely covered the crystalline rocks. Except quite close to the latter, no outliers of the former have been so far proved. Undoubtedly, before the old rocks were submerged beneath the Cretaceous sea, a drainage system, probably a mature system, had been established, and it is the relation between the pre-Cretaceous and post-Cretaceous rivers that presents many points of difficulty. The unfolded condition of the Cretaceous rocks in the immediate neighbourhood of the hills goes to prove that the post-Cretaceous movement was of the nature of a simple rise and fall. On elevation, the natural dip of the sediments, due to deposition and away from a partially buried land surface, would doubtless give rise to consequent streams flowing outwards to north, south, and west; but the observed dip is greater than that naturally due to deposition, and my impression is that the central part of the hills was elevated relatively to the edges, probably by a north and south movement, producing a more marked dome structure than could arise from simple uplift.

The post-Cretaceous streams would tend, after removal of the Cretaceous rocks, to revert to the earlier pre-Cretaceous lines of drainage. The rejuvenation which has resulted in the formation of the hanging valleys is, however, quite probably

* Taken by Mr. L. H. L. Huddart, A.M.I.C.E., A.R.S.M., etc.

due to a later movement, for the sands of Calabar (Benin Sands) stand at elevations of 100 to 300 feet above sea-level, and, as above indicated, are undoubtedly much later than Cretaceous in age.

Passing to the Southern Nigerian portion of the Kukuruku and associated hills, we notice as a characteristic feature of the scenery the occurrence of rounded knolls and ridges. In some instances, at least, these appear to be formed of harder rocks than those of the surrounding country, so we may conclude that in some instances, at least, they have resulted from differential erosion (monadnocks of American authors). Examples of such ridges are shown in Figs. 1 and 2, and attention may especially be drawn to the unusually level character of the remaining part of the country. Studying the plain from the top of one of these knolls or ridges, the enormous amount of denudation which must have taken place before this great, and in reality undulating, stretch of country could have been produced forces

FIG. 1.--HILL S.S.W. OF IDUANI, AKOKO HILLS.

itself upon the mind. The bed of the Ossi, a most important river, is, when viewed from such an elevation, a mere notch in the surrounding plain. The more luxuriant vegetation fringing the banks allows the eye to follow the curving course for a considerable distance. At the same time, it should be stated that when we view the hills themselves, as for instance from the path between Owo and Ipele, the rugged, steep-sided hills recall the Oban type of scenery. Like the latter, they are forested to the top.

The country to the west of Owo, towards Emure and Egpenni, carrying the drainage system of the Ogbese, recalls the drainage system of the Ossi lying between Owo and Ipele on the one hand, and the hills south of Iduani and Yayu on the other. In some instances, as in the little villages of Otua perched on steeply rising hills of hard schist, these elevated sites were chosen in older days as positions of defence from northern raiders.

The streams traversing this country are, as elsewhere, encumbered with rocks,

their courses are tortuous and the contained water exceedingly small in the dry season. Speaking generally, the relief is not nearly so pronounced on the west as on the east. Two peculiarities in the drainage system may be noticed here: the first is the small reservoir capacity of the catchment basin, occasioning quick rises in the water-level, and comparatively rapid falls in the amount of discharge; the second, the enormous amount of evaporation which must take place during the dry season. For many suggestions in connection with this subject I am indebted to my friend and late colleague, Mr. L. H. L. Huddart.

In a stream 60 or 70 feet in width the water is commonly but a few inches deep over the greater part of the bed, and in the heat of the tropical sun the evaporation must be very rapid. The interstitial water present in the sandy bed of the river is no doubt considerable, and in addition the slow process of filtration along the river floor may be important.

Much work requires to be done on the Cretaceous rocks, preceded by much exploration of at present untouched land, before the true history of this part of the physiography of Southern Nigeria becomes apparent, but in the Cross river basin some of the simpler phenomena may be briefly mentioned. A short excursion made in March from Akunakuna on the left bank of the Cross river to Abini, a distance of about 7 miles, served to show the great extent of the old flood plain.

It should be noted that the trend of the river there is roughly south-south-east, and that Abini lies approximately south-east from Akunakuna, the former town being mapped as about $3\frac{1}{2}$ miles due east of the bank of the Cross river. Leaving Akunakuna, the ground is at first swampy, with small outcrops of sandstone and now and again doleritic sills; this type extends for the first 3 miles from Akunakuna, and is doubtless covered more or less by water during the rains. Passing this old flood plain, we find a second extending towards Abini, forming now an undulating stretch of country, the ground littered with pebbles, mostly of quartz, up to 6 inches in diameter. That this gravel is part of the flood plain, and not formed by the disintegration of a pebble bed of Cretaceous age, is indicated by the presence of limestone and shale fragments. Coarse sandstones form conspicuous ridges trending east and west in the neighbourhood of Ungwana, Afikpo, and the Edda hills, and give rise to a rather bold type of scenery, the more prominent as the ground is not densely forested. The sandstone scarps are left at the village of Abba, half a day's march to the north of Afikpo, but even so the country is exceptionally interesting, and after a long sojourn in the forest even fascinating.

From the station of Afikpo, ridge after ridge of white and yellow sandstone may be seen stretching away into the distance, and the march northwards across the grain of the country is a succession of gentle ascents up the dip slopes and abrupt descents over cut raw edges.

At Abakalliki, the most northerly station yet opened in the Eastern Province, built on the remnants of a cretaceous volcano, a most interesting view is obtained. Below the hills of agglomerate and pumice lies the undulating plain formed of sandy shales, while some 60 miles to the south rise the sharp granite and gneiss peaks of the Oban hills. About the same distance to the east, and on the further side of the Aweyong river, a second jagged range, as yet unvisited by a white man, is most probably a northerly continuation of the same crystalline massif. A third exceedingly well-marked ridge may be seen about 30 miles to the north-north-east, and recalls by its rather flat top the sandstones of Afikpo rather than the granites and gneisses of the Oban hills. This surmise requires confirmation from actual work on the spot, and we can only say that around Abakalliki we have an undulating sparsely forested extent of country, assiduously cultivated, drained by a well-developed series

of streams trending generally north and south and emptying into the Cross river. Of these the Aweyong is the most important, but numerous unmapped streams, such as the Aboina, exist to the westward, occupying as usual meandering courses containing but little water in the dry season, their vertical banks, some 30 feet in height, cut through alluvium and shales. Traces of old and extensive flood plains, now cultivated or used for grazing, are not difficult to make out.

The coarse sandstones lapping round the granite and gneisses of the Oban hills, and succeeded by shales and thin limestones, do not usually give rise to any characteristic type of scenery, or, in the dense bush that envelops them, exhibit contours strikingly different from those of the central crystalline massif. It is, indeed, often difficult, even when prepared, to detect the junction between the two series of rocks. As in other parts, the valley-sides are very steep, and with care one can often make out that the path is running along the crest of a ridge, with a rather deep valley on either hand.

The last group of rocks, viz. the Tertiary sediments, forms, from the Niger westward, a lowlying, undulating stretch of country bordering the sea and gradually rising to the north. This is typically densely forested, frequently swampy; the river valleys characterized by exceedingly steep slopes, and their courses by the meanders and accumulations of sand, distinguishing streams which have worn down to their base-levels of erosion and are depositing on their lower reaches. The very prominent sandbanks, often raised to considerable height above the dry-weather level of the stream, and stretching with but little break for a mile or more along the bed of the river, are perhaps the most striking feature of the lower reaches of all the Southern Nigerian streams. On the Niger and on the Cross river they extend for great distances from the sea, and are a serious obstacle to travel even in a small dugout canoe, which at low water has to be dragged tediously from one reach to another. Anastomosing rivulets of water force their way through the sand, making it often a difficult matter to decide upon the deepest channel; while, owing probably to seasonal changes in the disposition of the sediment, the natives are almost useless as pilots. Frequently striking examples of horseshoe bends may be observed, but I have not noticed any instances of the still later cutting by the river along the chord of the arc to produce the so-called ox-bow lakes. It is probable that a closer examination of the delta region would prove the existence of more high ground than is usually suspected, but, owing to the dense bush and fringe of mangroves, it is difficult to judge of the country without close and laborious investigation. At Asaba, Calabar, and Adiabo, the Benin sands rise to heights of 200 or 300 feet above sea-level.

In a paper on the post-Cretaceous stratigraphy of Southern Nigeria, communicated to the British Association at the York meeting (1906), I pointed out that, with the exception of the alluvium now forming, these Benin sands are the latest deposits found, and that they undoubtedly indicate an important subsidence in late Tertiary times. With the succeeding elevation, also not unimportant, we may see the inauguration of the present drainage system, and from this, I believe, the present physiography dates.

The type of scenery is characteristic. We find a flat or undulating country, the lower parts often swampy, where later alluvium has accumulated round the hillocks of eroded Benin Sands, the ground never rising to any great height, and here and there trenched by streams contained in steep-sided valleys. Viewed from the river, the hills on which Calabar stands appear to be eroded out of a peneplain, and it is probable that, could the surface of the country be studied from a suitable elevation, such peneplains would be more obvious than is at present the case.

FIG. 2.—VIEW FROM TOP OF AKOKO HILLS.

The extensive system of lagoons is one of the most prominent features in the physiography of the Lagos Province. On the west it extends through Dahomey * and Togoland as far at least as Kwitta, on the Gold Coast, while on the east it joins the ramifications of the Olowa and Owena rivers, connected with the Gwato creek and the beginning of the delta of the Niger. The rise of the rivers emptying into the Lekki lagoon during the rainy season is stated by the natives to be 6 or 8 feet, and the sediment there discharged and spread out over the surface of the lagoon must be very considerable, and sufficient to cause a rapid silting up of the whole. In one or two places the common red clayey sands form small hills, some 40 feet in height, bearing the same relation to the Yoruba rivers as do the Calabar and Adiabo hills to the streams of the Eastern Province; but these little eminences are rare, and do not detract from the general flatness of the country.

On the lower reaches of all the Southern Nigerian rivers, alluvial flats jut out into the stream and fringe the higher ground of the valley. Many of these flats are probably just awash at high floods, when a thin layer of silt is doubtless laid down. Frequently they are occupied by the farms of the villagers; and the rows of broad-leaved plantains, cassava, or yams form a pleasant change from the forest-clad slopes of the valley rising behind the monotonous stretch of dirty, sluggish river.

THE STUDY OF SOCIAL GEOGRAPHY.†

By Prof. G. W. HOKE, Ohio State Normal College, Oxford, Ohio.

THE label "Made in America" would characterize the subject-matter of the following paper in part only, for much of it has been suggested by the writing of men on this side the sea, and no doubt many will recognize herein old friends and foes.

At the outset, it may be as well to confess that students of geography are embarrassed by the fact that there is no consensus of opinion as regards either subject-matter or method. From the geography whose worthy ideal is discovery and exploration to the geography whose subject-matter is the "organic response to an inorganic control," is so far a cry that they seem to have little in common. Nevertheless, all aspects of the subject deal with *distribution in space*. Such a programme is well defined, and is capable of harbouring the most widely divergent conceptions of the task of geography.

However, it is not the purpose of this paper to examine titles or to set boundaries. The following discussion will be based upon the proposition that social geography deals with the distribution in space of social phenomena, and that its working programme may be stated as the "description of the sequence and relative significance" of those factors, the resultant of whose influences is the localization in space of the series of social phenomena chosen for investigation. Ultimately, by comparison with similar situations, and the elimination of the accidental, generalizations may be derived which will be of value in predicting the future distribution of similar phenomena. The subject deals, therefore, with the facts and products of human association as represented by group characteristics, industries, institutions,

* See d'Albeça, "Le Dahomey en 1894," *Bull. de Géog.*, 1895, p. 185.

† Read at the York Meeting of the British Association, Section E, Geography, August, 1906.