
The Origin of the Major Features of the Geography of Northern Nigeria

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or January 4 (local time), by an earthquake of the first magnitude in Russian Turkestan. So violent was the disturbance that, in distant observatories, seismographs were displaced or injured. This was the case at Pulkova, and also in this country at West Bromwich, Cardiff, and Limerick. At Kew, though it is unusual for the magnetographs to register the passage of earthquakes, both the declination and horizontal force magnets were thrown into oscillation, the former beginning at 11.53 and the latter at 11.55 p.m. The first tremors were recorded by the Milne seismograph at Kew at 11.35 p.m., and the large surface waves at 11.47, when the limits of registration were exceeded for about a minute. This was followed by a lull in the great movements until about 11.54, when the limits of registration were exceeded, showing that the magnetographs were put into oscillation by the tilting of the ground. Nothing is known at present with regard to the limits of the area of destruction, but it certainly included Vyernyi and the northern shore of Lake Issil-Kul. The records of the Galitzin seismograph at Eskdalemuir place the epicentre in lat. 42° N., long. 77° E., that is, in the immediate neighbourhood of Lake Issil-Kul. The epicentral area must therefore coincide approximately with that of the great earthquake of June 9, 1887. Both are situated in a region of the most intense folding on the northern slopes of the Trans-Ilian Ala-tau, the axis of the epicentral area in 1887 being elongated in the direction of the folding. The Trans-Ilian Ala-tau range is one of those which constitute the Tian-shan mountains, the trend of which is concave to the north. The epicentral areas of the Vyernyi earthquakes thus lie, as is so frequently the case with other great world-shaking earthquakes, on the concave side of a mountain range, where the slopes are steepest and the crushing and sliding of the folded rock attain their chief development.

C. D.

THE ORIGIN OF THE MAJOR FEATURES OF THE GEOGRAPHY OF NORTHERN NIGERIA.*

By J. D. FALCONER.

THE salient features of the geography of Northern Nigeria are readily grasped (map, p. 183). The Protectorate is bounded on the north by the French Sudan, on the west by Dahome, on the south by Southern Nigeria, and on the east by the German Cameroons. The Niger and the Benue, with their tributaries the Kaduna and the Gongola, form the great waterways of the Protectorate, while the confluence of the two mighty rivers at Lokoja is counterbalanced, as it were, by the presence of Lake Chad in the north-eastern angle of the Protectorate. The south-eastern boundary runs through the rocky mass of the Shebshi hills, the Benue valley is limited to the north by the Wurkum and the Murchison hills, while the centre of the Protectorate is occupied by the great plateau of Bauchi, which rises to a height of over 4000 feet above the sea, and is marked off from the lower plains by precipitous walls on the north and south.

* Research Department, November, 17, 1910.

The scenery of Northern Nigeria bears in a general way a direct relationship to the character of the underlying rocks. Where horizontal sedimentary rocks, such as sandstones and grits, cover the surface, as in the valley of the Niger and on the lower and upper courses of the Benue, the typical scenery is that of low flat-topped ranges and plateau-like masses with narrow trench-like valleys and detached tabular and conical hills (Fig. 1). Where crystalline rocks form the surface rock, on the other hand, as in Hausaland, Borgu, Ilorin, Nassarawa and northern Yola, the characteristic type of scenery is that of the *inselberg* landscape, where open undulating plains are decorated by domes and turtle-backs of granite and isolated groups of rounded hills (Fig. 2). As exceptions to these rules, however, may be noted the middle Benue valley, where the great plain of Muri has been carved out of folded sand-stones, shales and limestones, and the belts of broken hilly ground which follow the strike of certain types of rock across the crystalline plains.

The Bauchi plateau whose surface presents all the characteristic features of a typical *inselberg* landscape is the hydrographical centre of the Protectorate (Fig 3). From it the rivers radiate north, south, east and west; but while at first they flow in such diverse directions they become ultimately included within one or other of the two great hydrographical systems, the Niger-Benue system and the Chad or Inland system. The primary watershed or dividing-line between the two great hydrographical systems runs from the northern boundary of the Protectorate to the east of Katsina southward with a sinuous course to the summit of the Bauchi plateau, whence it strikes north-eastward towards Bornu, and then south-eastward to the Yola border. Within the Chad system the only important river is the Yo, while the Yedseram, the only other large river of Bornu, forms, for some distance the boundary between Nigeria and the Cameroons. To the Niger-Benue system within the Protectorate belong a portion of the middle course of the Niger, with its larger tributaries the Kebbi, Kaduna, Gurara, Kampi and Mimi, and the middle and lower courses of the Benue, with its greater tributaries the Gongola, Tarabba, Donga, Katsena, Sungo and Okwa. In the west the primary watershed of the Niger system coincides approximately with the boundary of the Protectorate, while to the south of the Benue the primary watershed runs through Southern Nigeria and the Cameroons entirely beyond the limits of the Protectorate.

A striking peculiarity of the greater number of the rivers of Nigeria is that throughout their courses they present the exact reverse of the usual succession of mountain track, valley track, and plain track. Instead of drawing their headwaters from the slopes of jagged peaks they rise imperceptibly upon the swampy surface of elevated plains. Instead of flowing in their middle courses through ever-widening valleys they thread their way over gently undulating plains between and around the island mountains which decorate their surface: and instead of broadening out in their lower courses into wide and placid rivers with extensive flood plains on either hand, they flow with a rapid current in narrow trench-like valleys bounded by precipitous walls of rock. The hydrographical centre of the Protectorate, moreover, is not a group of rocky mountains, but the bare and treeless surface of an open plain, elevated 4000 feet above the sea. The primary watersheds are nowhere marked by ranges of jagged hills, but follow imperceptibly the crest lines of gently arching plains, and what hills there are appear to have had little or no influence in determining the courses of the greater rivers, and act only as secondary watersheds between the minor streams. The primary watersheds and the upper plains present all the characteristics of a mature topography, while the lower courses of the rivers, with their rapids and their trench-like valleys, exhibit an unexpectedly youthful appearance.

Another striking peculiarity of the surface of the Protectorate is that, contrary

to the rule in many parts of the tropics, any deep decomposition of the rocks *in situ* is a comparatively rare phenomenon. The little-weathered surface of the rocks is, however, deeply covered with a deposit of drifted or travelled alluvium which in places reaches a very considerable depth. The plains of Hausaland and Borgu owe their smooth and level surface very largely to this covering of drift, which obscures all the minor irregularities of the hummocky crystalline floor below and enwraps the bases of the scattered turtle-backs and isolated groups of hills. The rivers of Hausaland have cut their wide and shallow valleys in this sheet of drift, and are now actively engaged in its removal from the upper plains. Remains of similar deposits are found even on the highest parts of the Bauchi plateau, but, owing to the greater elevation, erosion is there more advanced, and only a few detached, flat-topped hillocks of drift are now left to tell the tale of its former extension (Fig. 4). These drift deposits of Northern Nigeria are nowhere now in process of accumulation. On the contrary, they are everywhere undergoing erosion. Their presence, however, affords some clue to the explanation of the peculiarities of the hydrography already indicated. It is abundantly evident that the drift deposits could not have accumulated upon the plains of Hausaland and upon the Bauchi plateau at their present elevation of 2000 to 4000 feet above the sea. On the contrary, they must have accumulated at a time when the surface of the Protectorate was at a much lower average level and at a time when the Bauchi plateau and the Nassarawa tableland had not assumed their present elevation above the plains of Hausaland, Nassarawa, and Muri. All the facts indeed point to an oscillatory movement of the crust in this part of Africa in late Tertiary or early Pleistocene times, as a result of which the surface of the Protectorate suffered alternate elevation and depression, with the consequently accompanying erosion and accumulation. The more recent movements may be summarized as: (1) a movement of elevation and consequent erosion during which a former sheet of weathered rock was removed from the surface of the Protectorate; (2) a movement of depression towards the close of which the drainage became uncertain and the drift deposits were spread out upon the surface of the Protectorate; and (3) a movement of elevation and accompanying erosion during a period which is continuous with the present.

It is to this most recent movement of elevation, which may be referred to the later Pliocene or early Pleistocene, that the establishment of the present river system is due. The elevation of the surface of the Protectorate from the neighbourhood of base level to an average height of 1000 feet above the sea was accompanied by a gentle flexuring of the crust into low arches and shallow troughs along axes which ran approximately W.S.W.-E.N.E. and N.N.W.-S.S.E. The two sets of flexures were produced practically simultaneously, and the present river system represents in a general way the adaptation of the drainage to the tectonic conditions resulting from the interference of the two sets of flexures (map, p. 183). The flexures may be termed respectively the α - and the β -flexures. Two α -arches, a northern and a southern, are distinguishable within the Protectorate. The northern runs from Borgu over the high plains of Kontagora, Sokoto and Katsina towards Machina and Zinder, and forms the watershed between the Gulbin Kebbi and its tributaries on the one hand and the Kaduna and the Yo on the other. These rivers may be presumed to occupy the shallow troughs on either side of the axial arch. The southern arch runs from central Kabba through Nassarawa and southern Bauchi into northern Yola, and the Benue may be presumed to occupy the trough to the south. Of the β -flexures, two axial arches may also be distinguished, a central and a western. The central is of a very partial character, and is recognisable only in the sinuous watershed which runs northward between the two α -arches from the

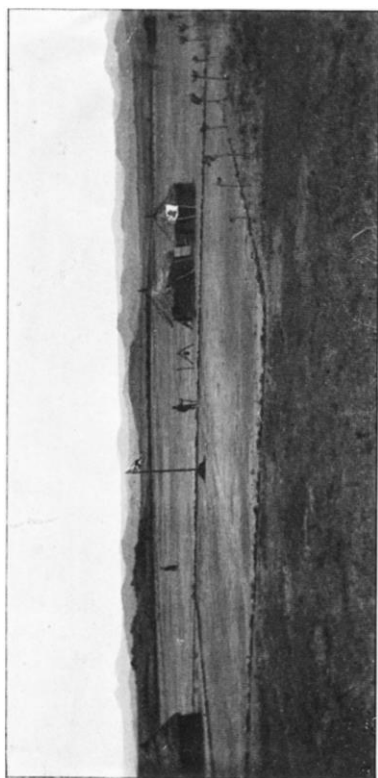


FIG. 1.—ON THE SUMMIT OF THE BAUCHI PLATEAU: THE PARADE-GROUND AT BUKURU.

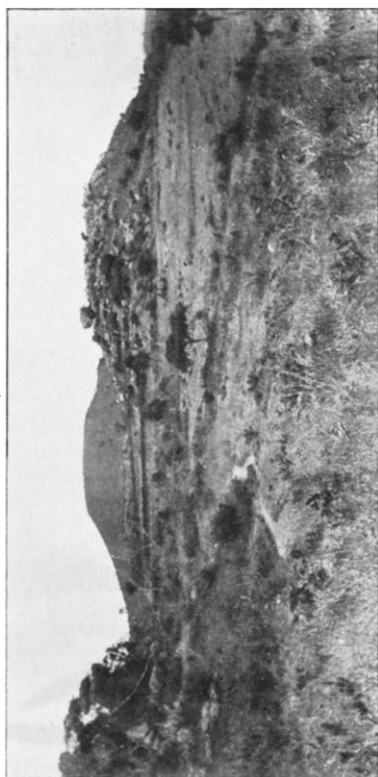


FIG. 2.—GRANITE KOPE AND HILLOCK OF DRIFT ON THE BAUCHI PLATEAU.

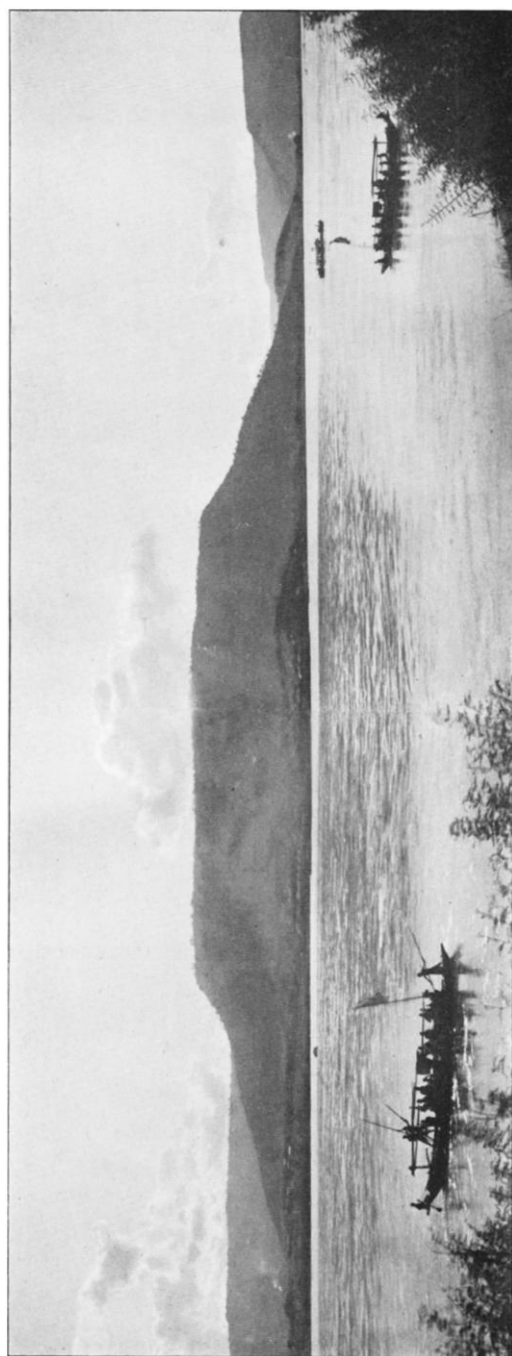


FIG. 3.—LOKOJA AND MOUNT PATTI.

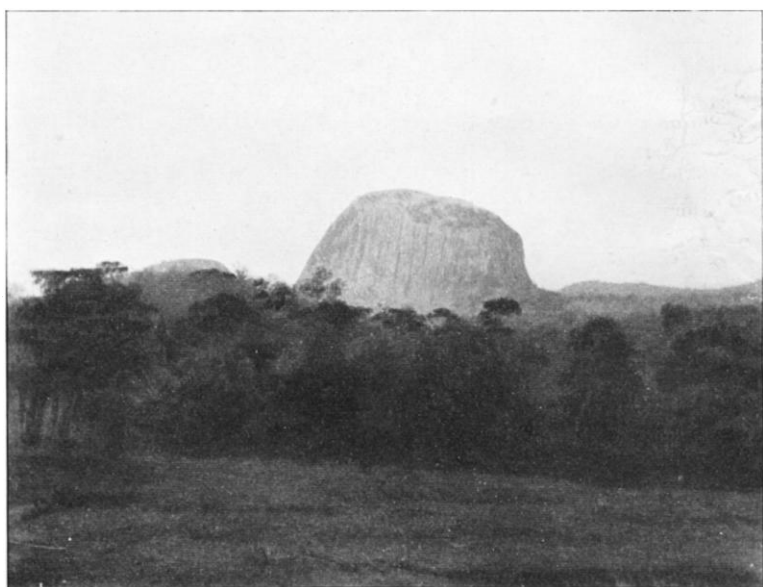
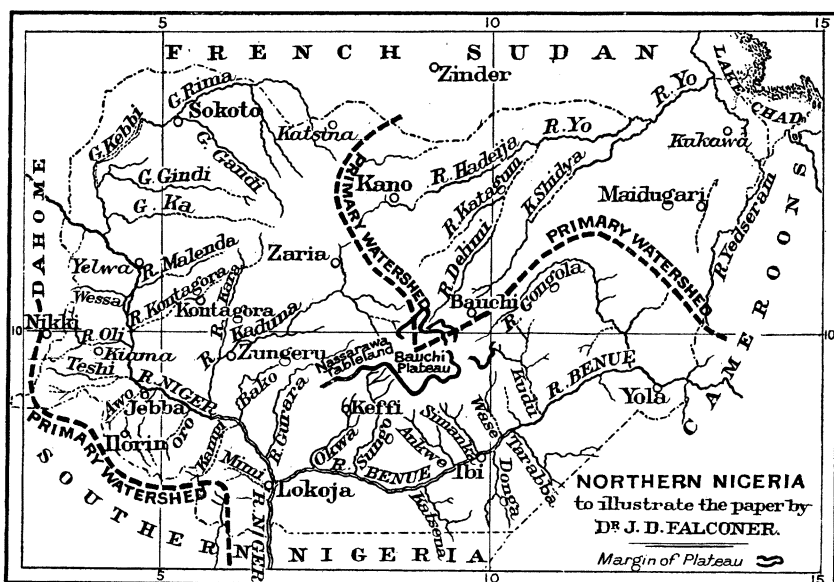
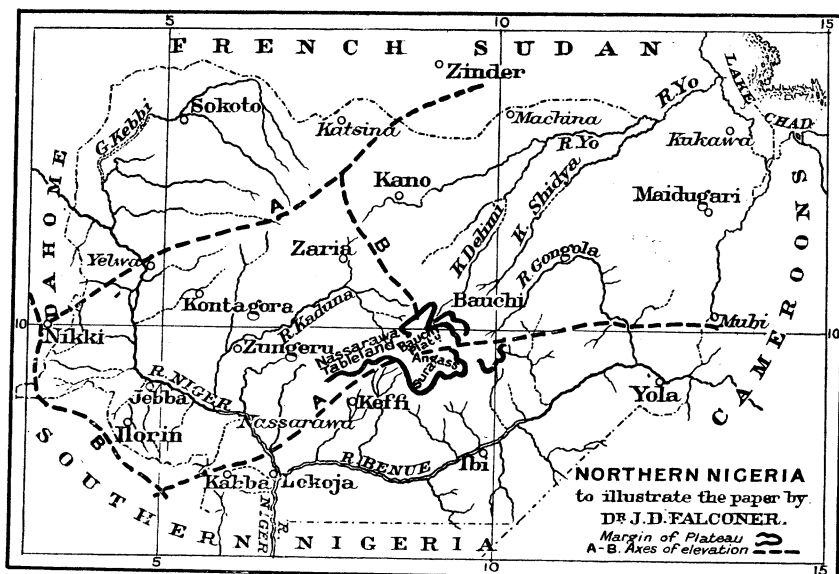


FIG. 4.—THE ABUJA ROCK. TYPICAL GRANITE MOUNT.

summit of the Bauchi plateau towards the Sokoto-Kano frontier, and separates the headwaters of the Kaduna from those of the Yo. The western arch forms in part



Nat. Scale 1:12,000,000 or 1 inch = 189.36 Stat. Miles 50 100 150 Statute Miles



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the western watershed of the Niger, and runs northward from the high plains to the south of Ilorin, approximately along the frontier of the Protectorate to the neighbourhood of Nikki in Dahomey.

The courses of the present rivers are thus clearly an adaptation to tectonic conditions. From the crests of the low extended arches the consequent streams were thrown off to pick a course for themselves over the drift-covered plains and between the solitary hills, and finally to unite to form the major rivers in the bottoms of the wide and shallow troughs. It should be remembered, however, that the elevation of the arches was in no sense catastrophic. The movement, for example, was evidently sufficiently slow to allow of the Niger cutting its way across the rising α -arches, a result which was rendered possible, however, only by the presence of soft and easily eroded sedimentary rocks in the river-bed. To the same reason also is to be ascribed very largely the contrast between the youthful character of the lower river-valleys and the matured aspect of the middle and upper courses. The trench-like valleys and dissected sandstone plateaux of their lower courses may reasonably be referred to the activity of the present rivers, but there can be little doubt that the turtle-backs and island mountains of the upper plains rose above the level surfaces of drifted alluvium long before the establishment of the present hydrographical régime. The central plains, indeed, possess an entirely antecedent character, and the rivers are only now beginning to cut their way slowly backward and downward into the harder crystalline rocks which form their floor. The whole drainage system, in fact, has suffered a complete reorganization and rejuvenation as a result of the recent elevation and flexuring of the surface of the Protectorate.

The river Gongola appears to have been diverted from its proper course towards Lake Chad by the presence of an earlier watershed in southern Bornu and northern Yola. The Chad area in the north-east occupies the trough between the two α -axes, and there is every reason to believe that, like the whole river system of Nigeria, the present lake is of comparatively recent origin, and in no sense a shrunken relic of an early Tertiary sea.

It is interesting also to trace the origin of the Bauchi plateau. The symmetrical elevation of the southern α -arch and the southward prolongation of the central β -arch were modified and interrupted by the formation of lines of weakness, longitudinally along the former and in the region of the intersection of the two arches. The relative influence of the forces which produced the flexures can be traced in the varying direction and sinuous character of the lines of weakness. Along these lines differential movements took place which resulted in the disproportionate elevation of the Nassarawa tableland and of the Bauchi plateau with reference to the middle Benue Valley and the northern plains of Bauchi. On the north the fracturing of the crust was confined only to the central region, while to the west and east the tableland and the plateau merged respectively into the general slope of the arch. On the south, however, a continuous line of fracture extended from Western Nassarawa by way of Darroro and Assab to Sura and Angass in Southern Bauchi. There is no reason to believe that the southern α -arch, as a whole, ever reached the elevation of the Bauchi plateau, or that the plateau originated in any sense as a "horst," separated from the adjoining tableland and the plains of Nassarawa and Muri by the later differential subsidence of the latter. On the contrary, the movement appears to have been in one direction only, and characterized by the differential elevation of the plateau and the tableland above the plains of Nassarawa, Muri and Northern Bauchi.

The isolated domes and kopjes and detached groups of hills which form the most striking feature of the higher plains are characteristic also of all the older gneissic areas of Africa, and the question of their origin has given rise to considerable difference of opinion. The particular type of scenery to which they give rise has been termed by German writers the "Inselberglandschaft." Passarge sees in them the product of arid conditions, and concludes that the surfaces which they characterize assumed their present character for the most part in early Mesozoic times when the

greater part of Africa was a barren desert. Bornhardt, on the other hand, believes that the *inselberge* have arisen as the result of the superposition of several cycles of erosion. There is, however, no reason to believe that this peculiar topography cannot arise simply through an alternation of periods of weathering and periods of erosion, brought about either by a gentle oscillation of the crust or by a repeated base-levelling of the plains and rejuvenation of the drainage system. A plane surface of granite and gneiss subjected to long continued weathering at base level would be decomposed to unequal depths according to the composition and texture of the various rocks. When elevation and erosion ensued the weathered crust would be removed and an irregular surface would be produced from which the more resistant rocks would project. Those rocks which had offered the greatest resistance to chemical weathering beneath the surface would upon exposure naturally assume that configuration of surface which afforded the least scope for the activity of the agents of denudation. In this way would arise the characteristic domes and turtlebacks, which suffer further denudation only through insolation and exfoliation. A slight subsequent movement of depression would suffice to cover with drift large areas of the irregular surface between the domes and to produce the characteristic topography of isolated and rounded hills rising abruptly from the level surface of the plains. It should be remembered, however, that, as already indicated, the *inselberge*, as we see them now, are of no very recent origin; and while it is unnecessary to go so far as to say with Passarge that they date back to pre-Cretaceous times, there can be little doubt that they are at least antecedent in origin to the present river system. This is indeed sufficiently obvious when it is remarked that the present courses of the rivers bear absolutely no relation to the position of the *inselberge*. The present rivers, indeed, are merely the result of the adaptation of the drainage to the changed tectonic conditions, and are in no sense responsible for the character or sculpture of the plains.

Prof. J. L. MYRES (before the paper): We begin this session of the Research Department with a paper by Dr. J. D. Falconer on the "Origin of the Major Features of the Geography of Northern Nigeria." The paper has been circulated for discussion, and I will ask Dr. Falconer to give us a summary of the main points in it, and to direct our attention to the questions on which he would most like criticism and discussion.

Dr. J. W. EVANS (after the paper): We must congratulate Dr. Falconer on his interesting account of a type of scenery which is still comparatively little known, and at the same time presents a number of important problems for solution. The hummocky plains he describes are by no means peculiar to Africa, for we find a very similar surface on the Deccan plateau in India, and, modified by ice action, in the great plains of Canada and Sweden, which consist, like those of Northern Nigeria, of gneiss and crystalline schists. This form of surface is not the result of the long-continued action of running water, but must be attributed to the decomposition of the rock by atmospheric agencies. On the north-eastern slopes of the Bolivian Andes below a height of 7000 or 8000 feet, where the rainfall is heavy and vegetation abundant, I found the slates converted into a soft red clay-like substance to a considerable depth, and under similar conditions all rocks containing aluminium silicates are acted on in this way. The resulting decomposed material is easily removed by streams or glaciers. The variations in the depth to which the decomposition has penetrated, may be explained by differences in the amount or kind of vegetation, in the saturation of the soil, and in other superficial conditions; but they are, no doubt, also determined to a considerable extent by the nature of the rocks and their jointing. Running water appears to preserve a rock from decomposition, though, of course, it exercises abrasive action upon it.