

THE GEOMORPHOLOGY OF BRITISH GUIANA

It seems necessary to reaffirm the postulates which Mr. Bracewell characterizes as "erroneous statements of fact", in my paper on British Guiana (*Geol. Mag.*, lxxvii, 1940, p. 300).

(1) HYDROGRAPHIC NOTES

The late Sir John Harrison and myself are charged with having misinterpreted the marine charts. Mr. Bracewell, however, admits that the information given by Admiralty Chart 1801—which has received certain revisions and corrections since the original edition—is meagre; and that he himself has not even seen the very useful Dutch charts of this coast. I believe he is correct in stating that the single 612 m. sounding, suggesting a protuberance, has been reproduced on p. 306 in error for a no-bottom observation; but this has no bearing on, and forms no part of, the matter discussed in the text. I see no reason, therefore, subject to the conditions indicated on page 308 of my paper, why the general position outlined therein or Harrison's opinion should be abandoned pending further hydrographic work. Such work is of the first importance in these continental studies, and in view of modern researches on submarine canyons it deserves to receive a great deal more attention in the future. Reference has been made (p. 310) to the bottom-carriage flow of sediment in the large rivers of British Guiana. In the light of Daly's¹ theory of submarine erosion by silt-laden waters transgressing the continental shelves, it is clear that much more remains to be said about this part of the South American coastal shelf, which has been subjected to elevation and subsidence in Cainozoic times. The depth of the Berbice channel may have to be considered in the light of this theory.

(2) KAIETEURIAN SANDSTONE BETWEEN THE ESSEQUIBO AND THE CORENTYNE RIVERS

The quotation from p. 320 of the paper given on p. 463 and again on p. 465 has been isolated from its context; and Mr. Bracewell's use of it suggests that he has not only misconstrued but has misrepresented the paper in his comments.

Firstly, the region between the Corentyne and Essequibo rivers from which the sandstone, if it ever existed, has been completely removed, is obviously not the same region as that where its presence is already indicated in published literature and maps cited by Mr. Bracewell. The region to which I referred, as is clearly shown on the general geological map, is that extending inland from the coast for a few degrees of latitude in the direction of the headwaters of these rivers and the southern boundary of the Colony. This is "the region of the Berbice downwarp where the rivers run northward to the sea, where there is no high plateau in the interior and from which region all the Kaieteur formation has disappeared"—as stated quite correctly on p. 325; this can be verified from the published maps.

¹ R. A. Daly, Glaciation and Submarine Valleys. *Nature*, p. 156, 7th February, 1942, vol. 149.

Secondly, nowhere in the paper is it implied that the tectonic features postulated: the axis of the Berbice downwarp and the Essequibo "break"—extended indefinitely southward into the heart of the continent. In contrasting differences of mineralization west and east of the Essequibo—while agreeing with Mr. Bracewell that a fracture across a big gneiss area will not improbably show gneiss on each side of the fracture—I remarked (p. 319): "The generalization . . . appears to be fair at any rate as far south as Lat. 5° N. or perhaps 4° N." On the same page I assigned an order of length to the supposed "Essequibo break" of 3° of latitude, which would include the portion extending, as I suggested, into the sea through the continental shelf.

The existence of Kaieteurian rocks near the headwaters of these rivers does not enter into the argument depending on their absence between the Essequibo and Corentyne rivers as and where indicated by the established work. Their headwaters are far south of the range of the postulated tectonic lines; while Mr. Bracewell himself appears to approve the idea of a crustal tilt with elevation in the south and depression toward the Berbice coastal region. In point of fact "the region of the Berbice downwarp" which makes its presence known chiefly through the embayment of the White Sand series, does not come into much prominence until north of Lat. 4° N.; and the little known headwater region to the south would rather fall into a province of elevation relative to the coast, not downwarp.

The hypotheses advanced are within a framework of accepted and published data, and their meaning should be plain enough if the paper is read in conjunction with a geological map of the Colony. Mr. Bracewell is not entitled, in his critique, to isolate statements and to disregard the limiting qualifications which surround them and any other generalizations I have made.

(3) THE ESSEQUIBO RIVER AS A COASTLINE BOUNDARY

Mr. Bracewell mentions irregular embayments of a former coastline at the foot of the Pakaraima mountains, due to the rivers flowing from that region; but he admits no evidence that the line of the Essequibo demarcated a coast. Surely such evidence is inherent in the topography and geology shown by the existing maps, and is demonstrated by the almost blatant contrast between the drainage systems east and west of this river, and the rise of the White Sand series to the west? One has only to visualize the consequences of changes in sea-level relative to the land. The White Sand has been recognized as far south as the Rupununi-Essequibo confluence (Lat. 4° N.). At present nearly one geographical degree of the lower Essequibo (the tidal portion below the Cuyuni) does form a coastline, with the pre-White Sand surface plunging to the eastward and northward below sea-level. A moderate general elevation or subsidence prior to or during the White Sand deposition would entail a shift of the sea-level contour (coastline) to the eastward or westward of the Essequibo, causing embayments of the sea up its western tributaries in the case of subsidence. Significantly enough the Essequibo would appear never to have received material tributaries from its eastern bank

north of Lat. 3° ; it certainly could not have done so in White Sand times, and in the period immediately preceding them; it does not do so now. A differential or tilting movement would introduce a north-south component in the shift of the sea-level contour, and thus explain the closure of the arc of the southern margin of the White Sand.

(4) DEPTH OF THE CRYSTALLINE FLOOR IN THE COASTAL REGION

My information regarding depths of unconsolidated rocks in the coastal region was obtained from the Geological Survey Office, Georgetown. I am not now in a position to refer to it more precisely; but from the quotation given on p. 317 of the paper it would appear that both Grantham and Noel-Paton accepted the figure of 1,680 feet in the identical work (*Geological Survey Bulletin*, No. 11) which Mr. Bracewell uses as evidence against the case. Why then has he refrained from mentioning this material statement from the same work? The depth of the sediment in the Berbice estuarine basin is of paramount importance in the evaluation of the theories now being discussed. Harrison estimated it at 3,000 feet, and mentioned the probability of a large old river channel, now deeply submerged, existing to the north. As stated on p. 317 of my paper, the question was then (1940) on the way to being settled by seismic and drilling work.

I have since been privileged to learn some of the results of this work, and understand that Mr. Bracewell has also been able to follow it. If that is the case some parts of his criticism are quite outside my comprehension; but the more recent data are not available for publication or discussion.

I believe Mr. Bracewell to be much out of order in opening a controversy while aware that essential relevant facts cannot, at any rate for the present, be used or made known either to meet criticism or to advance knowledge, and must be withheld.

The object of the paper was to test some hypotheses, which are flatly denied in the criticism, on the geomorphology of British Guiana. Any argument against them then must dispose of several important questions; for example, the contrast between the drainage systems east and west of the Essequibo, and the depth of the Berbice downwarp. The first of these Mr. Bracewell fails to explain; in the second case, the newer data are reserved from publication. Space forbids the discussion of further points, but I suggest (a) that a more careful reading of the paper in conjunction with the plans and literature cited will dispose of his charges of inaccuracy; (b) that he has isolated some of my remarks from their governing conditions, and has disregarded data from other sources. Such criticism cannot claim to be impartial. A more detailed statement of Mr. Bracewell's interpretation of the geomorphology, provided *all* the relevant data are included, will be welcome when conditions permit; but something more than mere dogmatic assertion will be required to prove or disprove any theory advanced.

I must here correct a wrong impression that may be conveyed by one of the published Geological Survey maps (G.S. No. 204, dated 1937, Groete Creek-Lower Cuyuni-Puruni Goldfield)—used in connection

with some of these studies. Part of this is stated (ref. No. 6 on the map) to have been compiled from my own mapping of the Puruni region. The part so published does not correspond in some material respects with the work that I undertook. I did not see the map in proof and was unaware before publication that a version differing from my own had been interpolated.

I should hesitate to suggest that any map based on scanty traverses cut through thick forest over difficult terrain was final, complete, or more than a first approximation to the truth ; but since the particular tract of country involved had not been mapped by any other workers, an explanation from Mr. Bracewell as Editor of the map is still awaited. The published version in part omits laterite cappings and extensive newer dolerites, and defines a relationship of a large dyke of the latter to the surrounding rocks, which was certainly never seen in the field. There will thus be a discordance between a portion of this map east of the Puruni River and my later map west of the Puruni which was completed for publication in June, 1940, but has not yet been issued.

An important question involved is that of the easterly extension of these great newer dolerites which play no small part in the control of drainage and land sculpture west of the Puruni. It is worth observing that if they have invaded the crystalline floor under the White Sand series east of the Essequibo, they may have contributed in no small measure to the formation of the low-level bauxite deposits which are such an outstanding feature in the tract between the Essequibo, Demerara, Berbice, and Corentyne rivers, and again in Suriname. The existence of large and sometimes frequent systems of sills and dykes, which may attain many miles in length, and some of which are certainly of post-Kaieeteurian age, provides further evidence of more extensive fracturing in the crystalline basement than has been accepted hitherto. The tilting of a continental block is but one stage toward the formation of fractures of the hinge-fault type ; and in the absence of very definite evidence to the contrary it would seem dangerous to accept the view that faulting has played no part in the determination of many of the geographical features of the country.

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