

the Constantinople earthquakes of July, 1894. The authorities were fortunate enough to secure the services as Director of Dr. G. Agamennone, whose excellent work as assistant in the Meteorological and Geodynamic Office of Rome is widely known among seismologists. The success achieved by him in one year proves that something good can even yet come out of the Ottoman Empire.

The first of the above-mentioned papers is a catalogue of forty-nine shocks felt in Turkey alone in 1894. This includes the Constantinople earthquake and many of its after-shocks. In the following year, Dr. Agamennone commenced the publication of monthly *Bulletins*, and at the same time widened the area of investigation so as to embrace all the countries bordering the eastern end of the Mediterranean. The third paper, published in the *Bulletins* for December, 1895, and January, 1896, contains a summary of the results for 1895. Instead of the 49 shocks chronicled in the previous year, we have no fewer than 400 observed in Turkey, 236 in Greece, 55 in Bulgaria, and 62 in the remainder of the region, making a total of 753, or about two a day. The majority of these are connected with several well-marked earthquake-centres, of which Dr. Agamennone discriminates thirty-one as having been in action in 1895. The Constantinople centre has sunk into relative unimportance, only ten shocks being known to have their origins in the neighbourhood of that city.

One of the most important earthquakes in 1895 was that felt at and near Paramythia during the night of May 13-14. Its intensity was between the degrees ix and x of the Rossi-Forel scale. At least seventy persons were killed, and more than 500 houses were destroyed, within an area of about 150 square miles. The shock was felt at Zante, about 110 miles from the epicentre, and was registered at several observatories in Italy, and also at Nicolaiew, in the south of Russia. From the times obtained at these places and near the epicentre, Dr. Agamennone estimates that the early tremors travelled at about 1.21 miles a second, and the larger pulsations at about 0.88 miles a second.

C. DAVISON.

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## CORRESPONDENCE.

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### THE PENEPLAIN OF THE SCOTCH HIGHLANDS.

SIR,—Your Magazine for last March contains an article by Messrs. Macnair and Reid that touches on a chapter in Scotch geology and geography which has interested me for some time past; but, unhappily, the few words of discussion that I contributed to the problem in a footnote to an article on a very different subject<sup>1</sup> seem to have been misunderstood by the above-named authors.

The problems discussed by Messrs. Macnair and Reid include a consideration of the geographical conditions obtaining in Scotland

<sup>1</sup> "The Development of certain English Rivers": London Geogr. Journ. 1895, p. 139.

during Old Red Sandstone time. Among these conditions, the form of the floor of ancient rocks on which the Old Red lies unconformably may be regarded as of prime importance.

The problem to which my attention had been attracted is the date and process of origin of the now uplifted peneplain in which the Scotch glens of to-day are carved. Judging by analogy with other peneplains, that of the Scotch Highlands can hardly have been longer exposed to dissection than since the latter part of Mesozoic time; indeed, Tertiary time alone may have been sufficient for the excavation of the narrow glens in the hard rocks of the Highlands, as well as for the more general denudation of the weaker rocks of the Lowlands. It is, therefore, not unreasonable, in my view of the matter, to regard the broad denudation by which the Highland peneplain itself was formed as having been completed in Cretaceous, or, at earliest, in Jurassic time. Whether this denudation was accomplished by marine or by subaerial agencies, or by the co-operation of both, I see no means of deciding definitely; but, for various general reasons, I incline to ascribe it chiefly to subaerial agencies.

Now, the reason that my brief footnote afforded material for quotation by Messrs. Macnair and Reid is, that I referred therein to the views of Sir A. Geikie concerning the date of the Highland peneplain, from which I took the liberty of dissenting; but I am at a loss to understand why a quotation from my footnote should be cited as "a very good example of the misconception and general indefiniteness which accompany Sir A. Geikie's description." If the brief note be misconceived and generally indefinite, the blame should fall on no one but myself.

In continuation, Messrs. Macnair and Reid seem to infuse their own views into my words when they say—"Professor Davis speaks of Devonian seas having cut down the Highlands to their base-level." On the contrary, I said that "Devonian erosion consumed a great volume of the contorted and overthrust rocks of the Highlands." Whether this erosion was marine or subaerial, is a difficult matter to decide, and I did not undertake to decide it. That the erosion of that time reduced the Highlands to base-level, was regarded as probable, but was not directly asserted.

Moreover, my use of the terms "Devonian" and "Old Red" was as synonyms—not for a moment as names of different times or of successive formations. Furthermore, I said nothing to justify the statement that "Professor Davis speaks . . . as if there were two distinct sets of rocks in Scotland, one marine . . . the other fresh-water." The question of the marine or lacustrine deposition of the Old Red (Devonian) was not raised in my note. On the other hand, I cannot justly take shelter under the statement of Messrs. Macnair and Reid that any error in my note "is quite excusable in one who has never studied the rocks of our country, but only read of them in the 'Scenery of Scotland,' for my reading extends much further; and while I have not "studied" the rocks on the ground, I have at least seen some of them. and in most enjoyable company, from the Buried pre-Torridonian mountains

on the shore of Loch Maree to the Carboniferous rocks of the Lowlands. But from these personal matters, let me turn again to the problem of the Highland peneplain.

It seems to me beyond dispute that a great denudation (whether marine or subaerial is here irrelevant) preceded the deposition of the Old Red (Devonian), because its lowest strata are strongly unconformable on their foundation. The place where the detritus furnished by this denudation was deposited is unknown; but this does not weaken the evidence of the denudation. The precise date of the denudation is not defined; it certainly preceded the deposition of the Old Red, but its chief accomplishment may have been at a considerably earlier date; indeed, after the greater part of the denudation had been effected, there may have been some deformation; and upon this deformed denuded surface, the Old Red deposition may have been begun. This can only be told by piecing together such fragments of the Old Red floor as are now in sight, restoring them to the position that they had at the beginning of Old Red deposition by allowing for the dip that the Old Red strata have since then gained, and then judging as well as may be whether the restored floor has the form of a surface of denudation or of deformation. Likely enough, this problem is not definitely soluble; but as far as I have read, the facts fully support the general statement that "a vast denudation was accomplished in earlier times than the Old Red Sandstone period." The contention that there was no such vast denudation does not seem to me well grounded. On the other hand, it seems equally indefensible to maintain that the surface produced by the very ancient pre-Old Red denudation is essentially identical with the once continuous peneplain of the Highland ridge-tops. Whatever even floor was produced before the beginning of Old Red deposition, it must be altogether lost to our sight by the significant deformation and the extensive denudation which have taken place since.

At the close of the Old Red period, some old-land areas may have remained above water (marine or lacustrine is immaterial in this connection). Around any such areas stretched the horizontal Old Red strata. But that condition is not presented to us; for the Old Red strata were at some later time more or less tilted, especially around the Grampians; and in this disturbance the foundation rocks must have shared with their cover. It is true that in certain districts the Old Reds have been little disturbed; but the dips that I have seen in the neighbourhood of Moray Firth are quite sufficient to have required a significant disturbance in the old-land floor, as well as in the Old Red cover. Hence it seems impossible to make the peneplain that is indicated by the existing ridge-tops of the Highlands agree with either the pre-Old Red floor, or with the old-land areas that may have remained above water at the end of Old Red deposition. Just what view Messrs. Macnair and Reid hold on this question I do not gather from their essay; but my reasons for differing from Sir A. Geikie do not seem to me to exhibit misconception or general indefiniteness.

Whatever peneplain is recognizable in the sky-line of the

Highlands, I believe it to have been produced after the post-Old Red deformation of the region; probably long afterwards. In some places it may by accident agree with the Old Red floor; but as a whole it must differ from that floor, because the floor was generally deformed after the Old Red strata were laid on it. Such coincidence is against all probabilities. It is altogether unlikely that a peneplain of so ancient a date as Middle Palæozoic time should have stood nearly level and close to sea-level until so comparatively late a date as just before the uplift that allowed the erosion of the glens.

It may be noted that the peneplain of the Highlands is of more imperfect form, of more difficult recognition, and hence attended with more uncertainty in explanation, than various other uplifted and dissected peneplains that I have seen: for example, that of the Ardennes and Hunsrück, or that of southern New England, or of western Pennsylvania and Virginia. The Scotch example must have been a rugged one at the best. Local study may perhaps identify certain peneplain areas that were well developed by the denudation that formed them when the region stood lower, and that are not yet altogether obliterated by the denudation that has been initiated since the region has risen to about its present height. The record of such a study I would gladly see. At the same time it might be possible to infer by what sort of uplift the peneplain gained its present order of altitude; whether by an arching, such as Hayes and Campbell have described for the uplifted peneplain of the southern Appalachians (*Nat. Geogr. Mag.*, Washington, vi, 1894, p. 63), or otherwise. It is perhaps to Scotch geographers rather than to Scotch geologists that one must look for a solution of this long-postponed problem; but the solution will be welcome whencesoever it comes.

HARVARD UNIVERSITY, *September*, 1896.

W. M. DAVIS.

#### THE PARALLEL ROADS OF GLEN ROY.

SIR,—If the “parallel roads” are marine raised beaches, they were accumulated between daily tide-marks, and as such are sure to differ in character from beaches accumulated at more or less fixed levels. Secondly, if the beaches were marine and rocky, one or other form of *Littorina* could scarcely be absent, and *Littorinas* are practically indestructible. In the loose sand of one at least of the Devonshire raised beaches, these shells occur in perfect preservation; *Littorina obtusata* is also said to occur in the deposits on Moel Tryfaen. If, then, the beach-deposits of the parallel roads of Glen Roy still survive, and no trace of *Littorina* can be found in them, the fact is hard to explain in such a sheltered valley, on the hypothesis that the accumulations are of marine origin. If, in addition to the absence of *Littorina* the beaches show no signs of being accumulated between tide-marks, the difficulty of accepting their marine origin will be greater still. The best evidence of a raised-beach platform is its sloping towards the water as part of an old tidal strand. Can such inclined planes be detected in the case of the parallel roads of Glen Roy?

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